CSE 579
Programming Assignment 1

Problem 1

Input Program	{pn(X,Y):Y=1..v}=1 :- X=1..v. :- pn(X1,Y), pn(X2,Y), X1!=X2. :- pn(X1,Y1), pn(X2,Y2), X1!=X2, |X1-X2|=|Y1-Y2|.
Command Line	clingo pa1q1.txt -c v=4 0
Output of clingo	clingo version 5.4.0 Reading from pa1q1.txt Solving... Answer: 1 pn(1,2) pn(2,4) pn(3,1) pn(4,3) Answer: 2 pn(2,1) pn(3,4) pn(1,3) pn(4,2) SATISFIABLE Models : 2 Calls : 1 Time : 0.018s (Solving: 0.01s 1st Model: 0.00s Unsat: 0.00s) CPU Time : 0.000s

Problem 2

<table>
<tr><td>Input
Program</td><td>{pn(X,Y):Y=1..v}=1 :- X=1..v.
:- pn(X1,Y), pn(X2,Y), X1!=X2.
:- pn(X1,Y1), pn(X2,Y2), X1!=X2, |X1-X2|=|Y1-Y2|.</td></tr>
<tr><td>Command
Line</td><td>clingo pa1q2.txt -c v=3 0
clingo pa1q2.txt -c v=4 0
clingo pa1q2.txt -c v=5 0
clingo pa1q2.txt -c v=6 0
clingo pa1q2.txt -c v=7 0
clingo pa1q2.txt -c v=8 0
clingo pa1q2.txt -c v=9 0
clingo pa1q2.txt -c v=10 0
clingo pa1q2.txt -c v=11 0
clingo pa1q2.txt -c v=12 0</td></tr>
<tr><td>Output
of clingo</td><td>Since the output is large, do not copy them into the submission.</td></tr>
<tr><td>Answer
to Questions</td><td>Draw a table that lists the number of solutions and the times to compute all solutions. Use CPU time that clingo returns.

<table>
<tr><th>Value n</th><th>Number of solutions</th><th>Time</th></tr>
<tr><td>3</td><td>0</td><td>0.02</td></tr>
<tr><td>4</td><td>2</td><td>0.012</td></tr>
<tr><td>5</td><td>10</td><td>0.023</td></tr>
<tr><td>6</td><td>4</td><td>0.029</td></tr>
<tr><td>7</td><td>40</td><td>0.286</td></tr>
<tr><td>8</td><td>92</td><td>0.738</td></tr>
<tr><td>9</td><td>352</td><td>0.844</td></tr>
<tr><td>10</td><td>724</td><td>1.602</td></tr>
<tr><td>11</td><td>2680</td><td>10.865</td></tr>
<tr><td>12</td><td>14200</td><td>58.308</td></tr>
</table>
</td></tr>
</table>

Problem 3

Input Program	% cell(X, c, Xes) cells(1,1,8).cells(2,3,3).cells(2,4,6).cells(3,2,7).cells(3,5,9).cells(3,7,2).cells(4,2,5). cells(4,6,7).cells(5,5,4).cells(5,6,5).cells(5,7,7).cells(6,4,1).cells(6,8,3).cells(7,3,1). cells(7,8,6).cells(7,9,8).cells(8,3,8).cells(8,4,5).cells(8,8,1).cells(9,2,9).cells(9,7,4). {cells(X,Y,V):Y=1..n, X=1..n, L2<=Y, Y<=L2+2, L1<=X, X<=L1+2}=1:-V=1..n, L2=3*(0..2)+1, L1=3*(0..2)+1. :- cells(X,Y1,V), cells(X,Y2,V), Y1!=Y2. :- cells(X1,Y,V), cells(X2,Y,V), X1!=X2. :- cells(X,Y,V1), cells(X,Y,V2), V1!=V2.
Command Line	clingo pa1q3.txt -c n=9 0
Output of clingo	clingo version 5.4.0 Reading from pa1q3.txt Solving... Answer: 1 cells(1,1,8) cells(2,3,3) cells(2,4,6) cells(3,2,7) cells(3,5,9) cells(3,7,2) cells(4,2,5) cells(4,6,7) cells(5,5,4) cells(5,6,5) cells(5,7,7) cells(6,4,1) cells(6,8,3) cells(7,3,1) cells(7,8,6) cells(7,9,8) cells(8,3,8) cells(8,4,5) cells(8,8,1) cells(9,2,9) cells(9,7,4) cells(2,1,9) cells(3,1,6) cells(1,2,1) cells(2,2,4) cells(1,3,2) cells(3,3,5) cells(4,1,1) cells(5,1,3) cells(6,1,2) cells(5,2,6) cells(6,2,8) cells(4,3,4) cells(5,3,9) cells(6,3,7) cells(7,1,5) cells(8,1,4) cells(9,1,7) cells(7,2,2) cells(8,2,3) cells(9,3,6) cells(1,4,7) cells(3,4,4) cells(1,5,5) cells(2,5,8) cells(1,6,3) cells(2,6,2) cells(3,6,1) cells(4,4,2) cells(5,4,8) cells(4,5,3) cells(6,5,6) cells(6,6,9) cells(7,4,9) cells(9,4,3) cells(7,5,7) cells(8,5,2) cells(9,5,1) cells(7,6,4) cells(8,6,6) cells(9,6,8) cells(1,7,6) cells(2,7,1) cells(1,8,4) cells(2,8,7) cells(3,8,8) cells(1,9,9) cells(2,9,5) cells(3,9,3) cells(4,7,8) cells(6,7,5) cells(4,8,9) cells(5,8,2) cells(4,9,6) cells(5,9,1) cells(6,9,4) cells(7,7,3) cells(8,7,9) cells(9,8,5) cells(8,9,7) cells(9,9,2) SATISFIABLE Models : 1 Calls : 1 Time : 0.028s (Solving: 0.01s 1st Model: 0.00s Unsat: 0.01s) CPU Time : 0.016s

Problem 4

Input Program	cells(1,1,9).cells(1,2,14).cells(2,1,6).cells(2,2,12).cells(3,1,4).cells(3,4,7).cells(4,2,15).cells(4,3,16).cells(5,2,7).cells(5,3,15).cells(6,1,5).cells(6,3,13).cells(7,2,8).cells(7,4,10).cells(8,1,16).cells(9,1,15).cells(10,2,9).cells(10,4,6).cells(11,1,2).cells(11,3,8).cells(12,2,13).cells(12,3,12).cells(13,2,5).cells(13,3,3).cells(14,1,8).cells(14,4,4).cells(15,1,10).cells(15,2,1).cells(16,1,11).cells(16,2,2).cells(1,6,3).cells(1,8,5).cells(2,6,14).cells(3,5,6).cells(3,8,13).cells(4,5,9).cells(4,6,7).cells(6,5,14).cells(6,7,15).cells(7,6,9).cells(7,7,4).cells(7,8,11).cells(8,5,5).cells(8,7,3).cells(9,5,16).cells(9,7,10).cells(10,6,5).cells(10,7,13).cells(10,8,3).cells(11,5,15).cells(11,7,14).cells(13,5,2).cells(13,6,16).cells(14,5,12).cells(14,8,1).cells(15,6,15).cells(16,6,8).cells(16,8,14).cells(1,9,15).cells(1,11,2).cells(2,11,10).cells(3,9,16).cells(3,12,1).cells(4,11,11).cells(4,12,6).cells(6,10,10).cells(6,12,3).cells(7,9,13).cells(7,10,6).cells(7,11,15).cells(8,10,14).cells(8,12,9).cells(9,10,9).cells(9,12,13).cells(10,9,1).cells(10,10,15).cells(10,11,4).cells(11,10,16).cells(11,12,12).cells(13,11,13).cells(13,12,10).cells(14,9,6).cells(14,12,7).cells(15,11,16).cells(16,9,3).cells(16,11,1).cells(1,15,7).cells(1,16,1).cells(2,15,5).cells(2,16,11).cells(3,13,2).cells(3,16,9).cells(4,14,3).cells(4,15,14).cells(5,14,2).cells(5,15,16).cells(6,14,1).cells(6,16,8).cells(7,13,14).cells(7,15,3).cells(8,16,6).cells(9,16,14).cells(10,13,7).cells(10,15,12).cells(11,14,5).cells(11,16,13).cells(12,14,9).cells(12,15,11).cells(13,14,12).cells(13,15,9).cells(14,13,15).cells(14,16,3).cells(15,15,6).cells(15,16,2).cells(16,15,10).cells(16,16,7). {cells(R,C,V):R=1..v, S2<=C, C<=S2+3, C=1..v, S1<=R, R<=S1+3}=1:- V=1..v, S2=4*(0..3)+1, S1=4*(0..3)+1. :- cells(R,C,V1), cells(R,C,V2), V1!=V2. :- cells(R1,C,V), cells(R2,C,V), R1!=R2. :- cells(R,C1,V), cells(R,C2,V), C1!=C2.
Command Line	clingo pa1q4.txt -c v=16 0
Output of clingo	clingo version 5.4.0 Reading from pa1q4.txt Solving... Answer: 1 cells(1,1,9) cells(1,2,14) cells(2,1,6) cells(2,2,12) cells(3,1,4) cells(3,4,7) cells(4,2,15) cells(4,3,16) cells(5,2,7) cells(5,3,15) cells(6,1,5) cells(6,3,13) cells(7,2,8) cells(7,4,10) cells(8,1,16) cells(9,1,15) cells(10,2,9) cells(10,4,6) cells(11,1,2) cells(11,3,8) cells(12,2,13) cells(12,3,12) cells(13,2,5) cells(13,3,3) cells(14,1,8) cells(14,4,4) cells(15,1,10) cells(15,2,1) cells(16,1,11) cells(16,2,2) cells(1,6,3) cells(1,8,5) cells(2,6,14) cells(3,5,6) cells(3,8,13) cells(4,5,9) cells(4,6,7) cells(6,5,14) cells(6,7,15) cells(7,6,9) cells(7,7,4) cells(7,8,11) cells(8,5,5) cells(8,7,3) cells(9,5,16) cells(9,7,10) cells(10,6,5) cells(10,7,13) cells(10,8,3) cells(11,5,15) cells(11,7,14) cells(13,5,2) cells(13,6,16) cells(14,5,12) cells(14,8,1) cells(15,6,15) cells(16,6,8) cells(16,8,14) cells(1,9,15) cells(1,11,2) cells(2,11,10) cells(3,9,16) cells(3,12,1) cells(4,11,11) cells(4,12,6) cells(6,10,10)

	cells(6,12,3) cells(7,9,13) cells(7,10,6) cells(7,11,15) cells(8,10,14) cells(8,12,9) cells(9,10,9) cells(9,12,13) cells(10,9,1) cells(10,10,15) cells(10,11,4) cells(11,10,16) cells(11,12,12) cells(13,11,13) cells(13,12,10) cells(14,9,6) cells(14,12,7) cells(15,11,16) cells(16,9,3) cells(16,11,1) cells(1,15,7) cells(1,16,1) cells(2,15,5) cells(2,16,11) cells(3,13,2) cells(3,16,9) cells(4,14,3) cells(4,15,14) cells(5,14,2) cells(5,15,16) cells(6,14,1) cells(6,16,8) cells(7,13,14) cells(7,15,3) cells(8,16,6) cells(9,16,14) cells(10,13,7) cells(10,15,12) cells(11,14,5) cells(11,16,13) cells(12,14,9) cells(12,15,11) cells(13,14,12) cells(13,15,9) cells(14,13,15) cells(14,16,3) cells(15,15,6) cells(15,16,2) cells(16,15,10) cells(16,16,7) cells(2,3,1) cells(4,7,1) cells(2,7,2) cells(4,4,2) cells(2,4,3) cells(3,10,3) cells(1,12,4) cells(2,5,4) cells(4,13,4) cells(3,3,5) cells(4,9,5) cells(1,14,6) cells(2,10,7) cells(1,4,8) cells(2,12,8) cells(3,15,8) cells(4,8,8) cells(2,9,9) cells(1,5,10) cells(3,2,10) cells(4,16,10) cells(1,3,11) cells(3,6,11) cells(1,13,12) cells(3,7,12) cells(4,10,12) cells(1,10,13) cells(2,14,13) cells(4,1,13) cells(3,11,14) cells(2,8,15) cells(3,14,15) cells(1,7,16) cells(2,13,16) cells(5,10,1) cells(7,5,1) cells(8,4,1) cells(6,9,2) cells(7,3,2) cells(8,6,2) cells(5,1,3) cells(5,9,4) cells(6,15,4) cells(8,3,4) cells(5,11,5) cells(7,16,5) cells(5,7,6) cells(6,2,6) cells(6,11,7) cells(7,14,7) cells(8,8,7) cells(5,5,8) cells(8,9,8) cells(5,13,9) cells(6,4,9) cells(5,8,10) cells(8,14,10) cells(5,12,11) cells(6,13,11) cells(8,2,11) cells(5,16,12) cells(6,6,12) cells(7,1,12) cells(8,11,12) cells(5,6,13) cells(8,13,13) cells(5,4,14) cells(8,15,15) cells(6,8,16) cells(7,12,16) cells(9,6,1) cells(11,15,1) cells(12,1,1) cells(9,15,2) cells(10,12,2) cells(12,8,2) cells(9,2,3) cells(11,11,3) cells(12,13,3) cells(9,14,4) cells(11,2,4) cells(12,6,4) cells(9,4,5) cells(12,10,5) cells(9,13,6) cells(11,6,6) cells(12,11,6) cells(9,3,7) cells(11,9,7) cells(12,5,7) cells(9,11,8) cells(10,14,8) cells(12,7,8) cells(11,8,9) cells(10,3,10) cells(11,13,10) cells(12,9,10) cells(9,9,11) cells(10,5,11) cells(11,4,11) cells(9,8,12) cells(10,1,14) cells(12,12,14) cells(12,16,15) cells(10,16,16) cells(12,4,16) cells(13,13,1) cells(14,10,2) cells(15,5,3) cells(13,16,4) cells(15,8,4) cells(16,10,4) cells(14,7,5) cells(15,12,5) cells(16,13,5) cells(13,8,6) cells(16,3,6) cells(13,1,7) cells(15,7,7) cells(13,10,8) cells(15,13,8) cells(14,11,9) cells(15,3,9) cells(16,7,9) cells(14,6,10) cells(13,7,11) cells(14,14,11) cells(15,10,11) cells(15,9,12) cells(16,4,12) cells(14,15,13) cells(15,4,13) cells(16,5,13) cells(13,9,14) cells(14,3,14) cells(15,14,14) cells(13,4,15) cells(16,12,15) cells(14,2,16) cells(16,14,16) SATISFIABLE Models : 1 Calls : 1 Time : 0.131s (Solving: 0.03s 1st Model: 0.00s Unsat: 0.02s) CPU Time : 0.109s

Problem 5

Input Program	cells(1,3,7).cells(1,7,8).cells(2,2,2).cells(2,8,4).cells(3,1,8).cells(3,3,4). cells(3,5,2).cells(3,7,5).cells(3,9,1).cells(4,5,7).cells(5,3,8).cells(5,4,3). cells(5,5,6).cells(5,6,4).cells(5,7,2).cells(6,5,9).cells(7,1,3).cells(7,3,2). cells(7,5,8).cells(7,7,7).cells(7,9,4).cells(8,2,7).cells(8,8,8).cells(9,3,6).cells(9,7,9). {cells(X,Y,V):X=1..v, Y=1..v,S2<=Y, Y<=S2+2, S1<=X, X<=S1+2}=1 :- V=1..v, S2=3*(0..2)+1, S1=3*(0..2)+1. :- cells(X1,Y1,V), cells (X2,Y2,V), X1\3==X2\3, Y1\3==Y2\3, X1!=X2, Y1!=Y2. :- cells(X1,Y,V), cells(X2,Y,V), X1!=X2. :- cells(X,Y,V1), cells(X,Y,V2), V1!=V2. :- cells(X,Y1,V), cells(X,Y2,V), Y1!=Y2.
Command Line	clingo pa1q5.txt -c v=9 0
Output of clingo	clingo version 5.4.0 Reading from pa1q5.txt Solving... Answer: 1 cells(1,3,7) cells(1,7,8) cells(2,2,2) cells(2,8,4) cells(3,1,8) cells(3,3,4) cells(3,5,2) cells(3,7,5) cells(3,9,1) cells(4,5,7) cells(5,3,8) cells(5,4,3) cells(5,5,6) cells(5,6,4) cells(5,7,2) cells(6,5,9) cells(7,1,3) cells(7,3,2) cells(7,5,8) cells(7,7,7) cells(7,9,4) cells(8,2,7) cells(8,8,8) cells(9,3,6) cells(9,7,9) cells(1,1,1) cells(2,6,1) cells(1,8,2) cells(1,6,3) cells(2,3,3) cells(3,8,3) cells(1,5,4) cells(1,2,5) cells(2,5,5) cells(1,4,6) cells(2,7,6) cells(3,2,6) cells(2,9,7) cells(3,4,7) cells(2,4,8) cells(1,9,9) cells(2,1,9) cells(3,6,9) cells(4,3,1) cells(5,8,1) cells(6,4,1) cells(4,1,2) cells(6,6,2) cells(4,2,3) cells(6,7,3) cells(4,7,4) cells(6,2,4) cells(4,4,5) cells(5,9,5) cells(6,3,5) cells(4,9,6) cells(6,1,6) cells(5,1,7) cells(6,8,7) cells(4,6,8) cells(6,9,8) cells(4,8,9) cells(5,2,9) cells(7,2,1) cells(8,7,1) cells(9,5,1) cells(8,9,2) cells(9,4,2) cells(8,5,3) cells(9,9,3) cells(8,4,4) cells(9,1,4) cells(7,6,5) cells(8,1,5) cells(9,8,5) cells(7,8,6) cells(8,6,6) cells(9,6,7) cells(9,2,8) cells(7,4,9) cells(8,3,9) SATISFIABLE Models : 1 Calls : 1 Time : 0.035s (Solving: 0.01s 1st Model: 0.00s Unsat: 0.01s) CPU Time : 0.016s

Problem 6

Input Program	cells(1,1,3).cells(1,9,4).cells(2,4,6).cells(2,6,9).cells(3,3,6).cells(3,7,9).cells(4,2,8). cells(4,4,3).cells(4,6,2).cells(4,8,6).cells(5,5,7).cells(6,2,1).cells(6,4,8).cells(6,6,5). cells(6,8,7).cells(7,3,7).cells(7,7,8).cells(8,4,7).cells(8,6,8).cells(9,1,9).cells(9,9,7). {cells(Y,X,V):X=1..v, Y=1..v, S2<=Y, Y<=S2+2, S1<=X, X<=S1+2}=1 :- V=1..v, S2=3*(0..2)+1, S1=3*(0..2)+1. :- cells(X,Y,V), cells(X+1,Y-2,V). :- cells(X,Y,V), cells(X+1,Y+2,V). :- cells(X,Y,V), cells(X-1,Y-2,V). :- cells(X,Y,V), cells(X-1,Y+2,V). :- cells(X,Y,V), cells(X+2,Y-1,V). :- cells(Y,X1,V), cells(Y,X2,V), X1!=X2. :- cells(Y1,X,V), cells(Y2,X,V), Y1!=Y2. :- cells(Y,X,V1), cells(Y,X,V2), V1!=V2. :- cells(X,Y,V), cells(X+2,Y+1,V). :- cells(X,Y,V), cells(X-2,Y-1,V). :- cells(X,Y,V), cells(X-2,Y+1,V).
Command Line	clingo pa1q6.txt -c v=9 0
Output of clingo	clingo version 5.4.0 Reading from pa1q6.txt Solving... Answer: 1 cells(1,1,3) cells(1,9,4) cells(2,4,6) cells(2,6,9) cells(3,3,6) cells(3,7,9) cells(4,2,8) cells(4,4,3) cells(4,6,2) cells(4,8,6) cells(5,5,7) cells(6,2,1) cells(6,4,8) cells(6,6,5) cells(6,8,7) cells(7,3,7) cells(7,7,8) cells(8,4,7) cells(8,6,8) cells(9,1,9) cells(9,9,7) cells(1,3,1) cells(2,2,2) cells(2,3,5) cells(5,2,5) cells(5,1,6) cells(4,1,7) cells(3,2,7) cells(3,1,8) cells(1,2,9) cells(7,1,1) cells(6,1,2) cells(5,3,3) cells(7,2,4) cells(6,3,4) cells(8,1,5) cells(8,2,6) cells(4,3,9) cells(9,2,3) cells(4,5,1) cells(3,6,1) cells(1,5,2) cells(3,5,3) cells(3,4,4) cells(1,4,5) cells(1,6,7) cells(2,5,8) cells(5,4,9) cells(8,3,2) cells(7,4,2) cells(5,6,4) cells(7,5,5) cells(6,5,6) cells(8,5,9) cells(9,4,1) cells(7,6,3) cells(9,5,4) cells(9,3,8) cells(2,9,1) cells(5,8,1) cells(5,7,2) cells(3,9,2) cells(2,8,3) cells(4,7,4) cells(3,8,5) cells(1,7,6) cells(2,7,7) cells(1,8,8) cells(8,7,1) cells(6,7,3) cells(8,8,4) cells(4,9,5) cells(5,9,8) cells(7,8,9) cells(6,9,9) cells(9,8,2) cells(9,7,5) cells(9,6,6) cells(7,9,6) cells(2,1,4) cells(8,9,3) SATISFIABLE Models : 1 Calls : 1 Time : 0.032s (Solving: 0.01s 1st Model: 0.00s Unsat: 0.01s) CPU Time : 0.016s

Problem 7

Input Program	gts(1,2,1,1).gts(1,3,1,2).gts(1,4,1,5).gts(1,6,1,5).gts(1,8,1,7).gts(1,9,1,8). gts(2,1,1,1).gts(2,2,1,2).gts(2,2,2,3).gts(1,3,2,3).gts(3,1,2,1).gts(3,1,3,2). gts(2,2,3,2).gts(3,3,3,2).gts(2,2,2,1).gts(2,4,1,4).gts(2,5,2,4).gts(2,5,2,6). gts(2,5,1,5).gts(2,5,3,5).gts(1,6,2,6).gts(2,6,3,6).gts(3,4,3,5).gts(3,5,3,6). gts(1,7,2,7).gts(3,7,2,7).gts(1,8,2,8).gts(3,8,2,8).gts(1,9,2,9).gts(2,9,3,9). gts(2,9,2,8).gts(2,8,2,7).gts(3,7,3,8).gts(3,9,3,8).gts(4,1,4,2).gts(4,3,4,2). gts(5,2,5,1).gts(5,2,5,3).gts(6,2,6,1).gts(6,2,6,3).gts(4,1,5,1).gts(6,1,5,1). gts(5,2,4,2).gts(5,2,6,2).gts(4,3,5,3).gts(6,3,5,3).gts(4,6,4,5).gts(4,5,4,4). gts(5,4,5,5).gts(5,6,5,5).gts(6,6,6,5).gts(6,5,6,4).gts(5,4,4,4).gts(5,4,6,4). gts(5,5,4,5).gts(5,5,6,5).gts(4,6,5,6).gts(6,6,5,6).gts(4,7,4,8).gts(4,9,4,8). gts(5,7,5,8).gts(5,8,5,9).gts(6,8,6,7).gts(6,8,6,9).gts(5,7,4,7).gts(6,7,5,7). gts(6,8,5,8).gts(5,8,4,8).gts(6,9,5,9).gts(5,9,4,9).gts(7,1,7,2).gts(7,3,7,2). gts(8,1,8,2).gts(8,2,8,3).gts(9,2,9,1).gts(9,2,9,3).gts(7,1,8,1).gts(8,1,9,1). gts(8,2,7,2).gts(9,2,8,2).gts(7,3,8,3).gts(9,3,8,3).gts(7,4,7,5).gts(7,6,7,5). gts(7,8,7,7).gts(7,8,7,9).gts(8,5,8,4).gts(8,5,8,6).gts(8,8,8,7).gts(8,9,8,8). gts(9,5,9,4).gts(9,5,9,6).gts(9,8,9,7).gts(9,9,9,8).gts(7,4,8,4).gts(9,4,8,4). gts(9,5,8,5).gts(8,5,7,5).gts(7,6,8,6).gts(8,6,9,6).gts(7,7,8,7).gts(8,7,9,7). gts(8,8,7,8).gts(8,8,9,8).gts(8,9,7,9).gts(8,9,9,9). {cells(X,Y,V):X=1..n, Y=1..n, S2<=Y, Y<=S2+2, S1<=X, X<=S1+2}=1 :- V=1..n, S2=3*(0..2)+1, S1=3*(0..2)+1. :- cells(X1,Y,V), cells(X2,Y,V), X1!=X2. :- cells(X1,Y1,N1), cells(X2,Y2,N2), gts(X1,Y1,X2,Y2), N1<=N2. :- cells(X,Y1,V), cells(X,Y2,V), Y1!=Y2. :- cells(X,Y,V1), cells(X,Y,V2), V1!=V2.
Command Line	clingo pa1q7.txt -c n=9 0
Output of clingo	clingo version 5.4.0 Reading from pa1q7.txt Solving... Answer: 1 gts(1,2,1,1) gts(1,3,1,2) gts(1,4,1,5) gts(1,6,1,5) gts(1,8,1,7) gts(1,9,1,8) gts(2,1,1,1) gts(2,2,1,2) gts(2,2,2,3) gts(1,3,2,3) gts(3,1,2,1) gts(3,1,3,2) gts(2,2,3,2) gts(3,3,3,2) gts(2,2,2,1) gts(2,4,1,4) gts(2,5,2,4) gts(2,5,2,6) gts(2,5,1,5) gts(2,5,3,5) gts(1,6,2,6) gts(2,6,3,6) gts(3,4,3,5) gts(3,5,3,6) gts(1,7,2,7) gts(3,7,2,7) gts(1,8,2,8) gts(3,8,2,8) gts(1,9,2,9) gts(2,9,3,9) gts(2,9,2,8) gts(2,8,2,7) gts(3,7,3,8) gts(3,9,3,8) gts(4,1,4,2) gts(4,3,4,2) gts(5,2,5,1) gts(5,2,5,3) gts(6,2,6,1) gts(6,2,6,3) gts(4,1,5,1) gts(6,1,5,1) gts(5,2,4,2) gts(5,2,6,2) gts(4,3,5,3) gts(6,3,5,3) gts(4,6,4,5) gts(4,5,4,4) gts(5,4,5,5) gts(5,6,5,5) gts(6,6,6,5) gts(6,5,6,4) gts(5,4,4,4) gts(5,4,6,4) gts(5,5,4,5) gts(5,5,6,5) gts(4,6,5,6) gts(6,6,5,6) gts(4,7,4,8) gts(4,9,4,8) gts(5,7,5,8) gts(5,8,5,9) gts(6,8,6,7) gts(6,8,6,9) gts(5,7,4,7) gts(6,7,5,7) gts(6,8,5,8) gts(5,8,4,8) gts(6,9,5,9) gts(5,9,4,9) gts(7,1,7,2) gts(7,3,7,2)

	gts(8,1,8,2) gts(8,2,8,3) gts(9,2,9,1) gts(9,2,9,3) gts(7,1,8,1) gts(8,1,9,1) gts(8,2,7,2) gts(9,2,8,2) gts(7,3,8,3) gts(9,3,8,3) gts(7,4,7,5) gts(7,6,7,5) gts(7,8,7,7) gts(7,8,7,9) gts(8,5,8,4) gts(8,5,8,6) gts(8,8,8,7) gts(8,9,8,8) gts(9,5,9,4) gts(9,5,9,6) gts(9,8,9,7) gts(9,9,9,8) gts(7,4,8,4) gts(9,4,8,4) gts(9,5,8,5) gts(8,5,7,5) gts(7,6,8,6) gts(8,6,9,6) gts(7,7,8,7) gts(8,7,9,7) gts(8,8,7,8) gts(8,8,9,8) gts(8,9,7,9) gts(8,9,9,9) cells(1,1,2) cells(1,2,3) cells(1,3,9) cells(2,1,4) cells(2,2,7) cells(2,3,6) cells(3,1,8) cells(3,2,1) cells(3,3,5) cells(1,4,5) cells(1,5,1) cells(1,6,4) cells(2,4,8) cells(2,5,9) cells(2,6,3) cells(3,4,7) cells(3,5,6) cells(3,6,2) cells(1,7,6) cells(1,8,7) cells(1,9,8) cells(2,7,1) cells(2,8,2) cells(2,9,5) cells(3,7,9) cells(3,8,3) cells(3,9,4) cells(4,1,9) cells(4,2,6) cells(4,3,7) cells(5,1,1) cells(5,2,8) cells(5,3,2) cells(6,1,3) cells(6,2,5) cells(6,3,4) cells(4,4,3) cells(4,5,4) cells(4,6,8) cells(5,4,9) cells(5,5,5) cells(5,6,6) cells(6,4,1) cells(6,5,2) cells(6,6,7) cells(4,7,5) cells(4,8,1) cells(4,9,2) cells(5,7,7) cells(5,8,4) cells(5,9,3) cells(6,7,8) cells(6,8,9) cells(6,9,6) cells(7,1,7) cells(7,2,2) cells(7,3,8) cells(8,1,6) cells(8,2,4) cells(8,3,1) cells(9,1,5) cells(9,2,9) cells(9,3,3) cells(7,4,6) cells(7,5,3) cells(7,6,9) cells(8,4,2) cells(8,5,7) cells(8,6,5) cells(9,4,4) cells(9,5,8) cells(9,6,1) cells(7,7,4) cells(7,8,5) cells(7,9,1) cells(8,7,3) cells(8,8,8) cells(8,9,9) cells(9,7,2) cells(9,8,6) cells(9,9,7) SATISFIABLE Models : 1 Calls : 1 Time : 0.222s (Solving: 0.19s 1st Model: 0.17s Unsat: 0.03s) CPU Time : 0.156s

Problem 8

Input Program	{bishop(X,Y)} :- X=1..v, Y=1..v. :- bishop(X1,Y1), bishop(X2,Y2), X1!=X2, |X1-X2|=|Y1-Y2|. #maximize{1,X,Y: bishop(X,Y)}.
Command Line	clingo pa1q8.txt -c v=3 0 clingo pa1q8.txt -c v=4 0 clingo pa1q8.txt -c v=5 0 clingo pa1q8.txt -c v=6 0 clingo pa1q8.txt -c v=7 0 clingo pa1q8.txt -c v=8 0
Output of clingo	bishop(1,1) bishop(1,3) bishop(2,1) bishop(2,3) Optimization: -4 OPTIMUM FOUND Models : 5 bishop(1,1) bishop(1,2) bishop(1,3) bishop(1,4) bishop(4,2) bishop(4,3) Optimization: -6 OPTIMUM FOUND Models : 7 bishop(1,1) bishop(1,2) bishop(1,5) bishop(2,5) bishop(3,1) bishop(3,5) bishop(4,1) bishop(5,4) Optimization: -8 OPTIMUM FOUND Models : 9 bishop(1,3) bishop(1,4) bishop(2,1) bishop(2,6) bishop(5,1) bishop(5,6) bishop(6,1) bishop(6,3) bishop(6,4) bishop(6,6) Optimization: -10 OPTIMUM FOUND Models : 11 bishop(1,4) bishop(1,5) bishop(1,7) bishop(2,1) bishop(2,7) bishop(3,1) bishop(5,7) bishop(6,1) bishop(6,7) bishop(7,3) bishop(7,4) bishop(7,7) Optimization: -12 OPTIMUM FOUND Models : 13 bishop(1,1) bishop(1,2) bishop(1,6) bishop(2,8) bishop(3,1) bishop(4,1) bishop(4,8) bishop(5,1) bishop(5,8) bishop(6,8) bishop(7,1) bishop(8,1) bishop(8,3) bishop(8,7) Optimization: -14 OPTIMUM FOUND

<table>
<tr><td></td><td>Models : 15</td></tr>
<tr><td>Answer
to Questions</td><td>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.

<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>
f(n) = 2*(n-1)</td></tr>
</table>

Problem 9

Input Program	{asn(A,1..v)}=1:-A=1..n. :- asn(A,C),asn(B,C),asn(A+B,C),A!=B.
Command Line	clingo pa1q9.txt -c v=1 -c n=2 clingo pa1q9.txt -c v=2 -c n=8 clingo pa1q9.txt -c v=3 -c n=23 clingo pa1q9.txt -c v=4 -c n=66
Output of clingo	clingo version 5.4.0 Reading from pa1q9.txt Solving... Answer: 1 asn(1,1) asn(2,1) SATISFIABLE Models : 1 Calls : 1 Time : 0.002s (Solving: 0.00s 1st Model: 0.00s Unsat: 0.00s) CPU Time : 0.000s clingo version 5.4.0 Reading from pa1q9.txt Solving... Answer: 1 asn(1,1) asn(2,1) asn(3,2) asn(4,1) asn(5,2) asn(6,2) asn(7,2) asn(8,1) SATISFIABLE Models : 1+ Calls : 1 Time : 0.005s (Solving: 0.00s 1st Model: 0.00s Unsat: 0.00s) CPU Time : 0.000s clingo version 5.4.0 Reading from pa1q9.txt Solving... Answer: 1 asn(1,2) asn(2,2) asn(3,3) asn(4,2) asn(5,3) asn(6,3) asn(7,3) asn(8,2) asn(9,1) asn(10,1) asn(11,2) asn(12,1) asn(13,1) asn(14,1) asn(15,1) asn(16,2) asn(17,1) asn(18,1) asn(19,3) asn(20,1) asn(21,3) asn(22,2) asn(23,3) SATISFIABLE Models : 1+ Calls : 1 Time : 0.017s (Solving: 0.01s 1st Model: 0.01s Unsat: 0.00s) CPU Time : 0.016s

<table>
<tr><td></td><td>clingo version 5.4.0
Reading from pa1q9.txt
Solving...
Answer: 1
asn(3,3) asn(1,4) asn(2,4) asn(4,4) asn(5,3) asn(6,3) asn(7,3) asn(8,4)
asn(9,1) asn(10,1) asn(11,4) asn(12,1) asn(13,1) asn(14,1) asn(15,1)
asn(16,1) asn(17,1) asn(18,1) asn(19,3) asn(20,1) asn(21,3) asn(22,4)
asn(23,3) asn(24,2) asn(25,4) asn(26,2) asn(27,2) asn(28,2) asn(29,2)
asn(30,2) asn(31,4) asn(32,2) asn(33,2) asn(34,2) asn(35,2) asn(36,2)
asn(37,2) asn(38,2) asn(39,2) asn(40,2) asn(41,2) asn(42,2) asn(43,2)
asn(44,2) asn(45,2) asn(46,2) asn(47,2) asn(48,2) asn(49,2) asn(50,4)
asn(51,3) asn(52,3) asn(53,3) asn(54,1) asn(55,1) asn(56,1) asn(57,1)
asn(58,1) asn(59,4) asn(60,1) asn(61,1) asn(62,1) asn(63,3) asn(64,3)
asn(65,3) asn(66,4)
SATISFIABLE

Models : 1+
Calls : 1
Time : 581.776s (Solving: 581.71s 1st Model: 581.70s Unsat: 0.00s)
CPU Time : 557.047s</td></tr>
<tr><td>Answer
to Questions</td><td>Fill in the values accordingly.

<table><tr><td>Exact value of A(1)</td><td>2</td></tr><tr><td>Exact value of A(2)</td><td>8</td></tr><tr><td>Exact value of A(3)</td><td>23</td></tr><tr><td>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.</td><td>66</td></tr></table></td></tr>
</table>