															тi	mo	_	61	200	00	Νı	ımh	or	of		ra	t o	rc	_	20																
х	Х		Х				Х	- :	X				х	Х	-	-		-	-	-	- ·	-	-	-	-	- -	-	X :	×	23				х	-	-	-	-	-	-	-	-	-	-	-	-
X		X			0			X			0			X	X	-		-	-	-	_ :		-	-	-	_	- :	X :	X X		0			X	_	- x	- x	- x	- X	×	-	-	-	-	-	-
Х		Х			Ī			Х			-			х	Х	-		-	-	-		-	-	-	-	-	Х		>	(х	-	-	Х				Х	Х	-	-	-	-	-
X	X	_	X	~	~	~	~	_ '	~				v	~	_	_		_	_	_		_	_	_	_	_	~		٠.	/ V	X	X	X	-	X			0			X	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-			-	-	-	X		^ .	` >	` х	X	-	-	-	X			•			Х	Х	х	х	Х	х
-	-	-	X	Х	Х	X	X	-	-	-	X	Х	Х	Х	X	-		-	-	-		-	-	-	X			^		X		-	-	-	-	X				X	Χ	X	Х			
-	_	X	Х			X	х	Χ.	Х	X	Х				Х	x		-	-	_			X	X	X			U		X	(- (-	_	-	-	_	- -	X	X	X	Х		X			0	
Х	Х	Х	Х		Х			_			х		0			Х		-	-	-	- : - :	-	Х			Х			>	(-	-	-	-	-	-	-	-	-	Χ			Х				
			Х	x	X			0			X				x	X -		-	-	_	- 3 X X X - 3	(X	Х	Х	X X	Х	X	X : X	× >		_	-	-	-	_	_	-	-	X -	x			X	x	x	x
	0			Х		х				х	х	х	Х	х	Х	-		-	-	-	X					Х	Х	X :	x -	-	-	-	-	-	-	-	-	-	-	Х	Х	х	х	Х	-	-
			¥	X		Х	Х	X :	X	X	X	X	X -	X	-	-		-	-	-	X X		0			X			x -	, -	_	-	-	-	_	-	-	-	-	-	-	-	-	-	-	-
х	х	х	X	-	х			^	X	-	-	-	-	_	-	-		-	-	_	- ;	(х	^	0		>	(-	-	_	-	-	-	_	-	-	-	_	-	-	_	-	-	_
-	-	-	-	-	Х	Х	Х	X	X	-	-	-	-	-	-	-		-	-	-	- 3 	(X	Х	Х	Х				. >	(-	-	-	-	-	-	-	Х	Х	Х	Х	Х	-	-	-	-	-
_	-	-	-	_	-	-	_	-	-	-	-	-	_	-	-	-		-	-	-			-	-	X	х	х	x :	х - х -	· x		×	X	x	_	×	Х				Х	X	-	-	_	-
-	-	-	-	-	-	Х	х	X	X	х	-	-	-	-	-	-		-	-	-		-	-	-	-	-	-	-		· x	(Х	-	Х			0			Х	-	-	-	-
-	-	-	-	-	-	Х				Х	-	-	-	-	-	-		-	-	-			-	-	-	-	-	-	- >	,		^			X	Х	_				v	Х	-	-	-	-
_	-	_	-	_	X			0			X	_	_	_	x	- x :	 x x	X	-	_	- ,	(X	X	X	x	-	_	-	- <i>/</i> - >	(U			x	_	x	х	х	х	X	-	-	-	-	_
-	-	-	-	-	Х						Х	-	-	-	Х			Х	-	-	Х			Х		Х	-	-		· X	(Х	-	-	-	-	-	-	-	-	-	-	-	-
-	- ×	- x	- x	- x	- x	X	×	x	x	X	-	-	-	X)		X	X		0			X	X	-	-	- :	· ×	. X	- -	X -	X -	_	-	-	-	X	Х	Х	Х	X	-	_	-
-	Х	^	^	^	Х	-	-	-	-	-	-	-	-	Х			•		Х	Х		·			х	-	- :	x :	x >	×	Х	-	-	-	-	-	х	х	^				^	Х	-	-
X			0			X	-	-	-	X	X	Х	Х	Х	X			X	-	-	X	, ,	_	X	Х	X	- :	X			Х	-	-	-	-	-	Х	X			0			X	-	-
×			U			X	-	- :	x	X	^				^	х Х		-	-	-	X		^	^		X	x :	x :	x >	(X	-	-	_	X		^	х				х	-	_	_
-	Х				Х	-	-	- :	X	Х			0			Х		-	-	-	-)	(Х	Х			>	(Х	Х	Х	X	Х			Х	Х	Χ	Х	х	-	-	-
-	X	X	X	X	X	-	-	- :	X -	X	v				¥	X -		-	X	Х	X)	(X Y	X	X	X			n		X	X				X	- Y	X	¥	¥	Y	X	-	-	-	_	-
х	х	Х	-	_	-	_	x	X	X	x	x	х	х	х	x	-		Х	^			^	Х	-	x			0		×	X	х	х	х	X	^	^	^	x	-	-	-	_	-	-	_
		Х	-	-	-	-	Х				Х	-	-	-	-	-		Х			0		Х	-	-	Х				(X	X				X		_			Х	-	-	-	-	-	-
0			X	_	-	X			0			X	_	-	-	_		- -	х			х	- -	-	_	× -	× .	× .	x >	· x	((0			X X	U			X	×	×	×	x	×	-
			Х	-	-	Х						Х	-	-	-	-		-	Х	х	X X	(X	-	-	-	-	-	-		×						Х			х	-	Х				Х	-
_	~	X	-	-	-	-	X	_	~	~	X	-	-	-	-	-		-	-	-	- :		-	-	-	-	-	-		-	X	_	~	_	X	X	X	X	X	X			0			X
X	^	^	^	x	^	^	^	X	-	-	-	_	-	_	-	-		-	-	_			-	-	_	_	_	-			-	-	-	-	-	_	-	-	-	x			٠			x
.,												-						-	-	-	-	-	-	-	-	-	-	-		-	-	-	-												Х	-
Х	Х		X			0				_	-	-	_			-					- :													-	_	_	-	x	х					X		
			Х	Х				Х	-	-	-								-	-		-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	Х			0			X X	-	-
0																					- :																						_	Х	-	-
		Х																																												
Х	Х	Х	-	Х	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
																															_															
															Τi	me	=	90	900	00	Νι	ımb	er	of	C	ra	te	rs	=	49	0.0															
х	х		x				x	- :	x				х	х	Ti -	me -	=	9(X	906	00	Νι 0	ımb	er x	of -	- C	ra -	te x	rs	= (49)	0.0	х		х	-	-	-	-	х						х	-
×	х	×	x		0		×	- : X	X	×	×		x	X X	Ti - X X	me - -	=	90 X X	900 ×	00	Νι Ο	ımb	er x x	of - -	- - -	ra - -	te x x x	rs: x	= (49).0 ×	x x		X X X	-	- - x	- - x	- - x	X X X			0			X X X	-
X X X	x	X X X	х		0		x x x	- : X X	x x	x	x x		x	X X X	Ti × × x	me - - -	= 	9(X X -	906 × ×	00 x	N1 0	ımb ×	er X X -	of - - -	- - - -	ra - - -	te x x x x	rs: x x :	= c	49) (x).0 ×	X X	x	X X X	- - -	- - X X	- - X	- - X	x x x	x		0		×	x x x	-
X X X X	x	X X X	x		0	X	x x x	X X	x x	×	x x	×	×	X X X X	Ti × × × -	me - - - -	= 	9(X X - -	906 × × -)0 × -	Ni 0 × ×	x x 	er	of - - -	- - - -	ra - - - -	te x x x x x	rs: x x	= (x	49) (x	x x x x	x x	x x	X X X	- - - X	- X X	- - X	- X	X X X	× ×	x	0 x	X	x x	x x x -	
x x x x	x x x	x x x	x x x	×	0 x	× × ×	× × ×	X X	× ×	×	x x	× × ×	× × ×	× × × × ×	Ti x x x - -	me - - - -	= 	9(X X - - -	906 × × - -)O × - -	Nt 0 × 2 - 3	x x - x x	er X - - X	of - - - - x	- - - - X	ra - - - - x x	te x x x x x x	rs: x x :	= (×	49) (× × × × × ×	x x	x x -	X X - -	- - - X X	- × ×	- - X	- X 0 X	× × ×	×	×	0 x	××	x x - x	X X - - X	X
X X X X	x x x	× × ×	× × × ×	×	0 x - x	× × ×	× × ×	x x	x x 0	×	× ×	× × ×	x x x - x	× × × × ×	Ti - X X - - - X	me - - - - -	 	90 X X - - -	906 × × - -	×	NI 0 × 2 - 2 - 2 ×	x x x x x	er x - - x	of - - - x	- - - - X X	ra - - - X X	te x x x x x x	rs: x x :	= (× > × > × >	49) (× (×	x x x x x x x x x	x x x - - x	× × - ×	X X - - - X	- - - X X X	- - × ×	- - X	- × 0 ×	x x x	××	x 0	0 ×	×	× × - × ×	× × - - ×	- - - X
x x x x 	x x 	X X X 	x x x - x	x - x	0 × - ×	x x x x x	x x x	- : x x	x x o	X X X	x x x	x x x	x x x - x	x x x x x x	Ti - X X - - - X	me - - - - - - - - - - - - - - - - - - -	=	90 X X - - - -	900 × × - - -	X	NI 0 × 2 - 2 - 2 × x × x	x x x x	er x - - x	of - - - - x	- - - X X	ra - - - X X X	te x x x x x x	rs: x x x	= C × > × >	49) (. 0 × × × × × × × × × × ×	x x x x	× × - ×	× × - - - ×	- - X X X	X X X	- X	x 0 x x x x x	x x x x	××	× 0	0 ×	X X	x x - x x	x x x - - x	- - - - X
X X X X 	x x x	x x x x x x x	x x x x x	× - ×	0 x - x	x x x x x	x x x	- : X X X X X X X X X X X X X X X X X X	x x 0 x	x x x x	x x x x	x x x x	x x x - x	X X X X X	- X X X - - X X	- - - - - X		× × - - - - - -	X X - - -	X	0 × 2 - 3 - 3 × x × x	× × × × × ×	x x - - x	- - - X	- - - X X	- - X X X X	X X X X X	x x : x :	× > × > × >) (× × × × × × ×	x x x	x x - x	X X - - - X	- - - X X X	X X X	×	- x 0 x x x	x x x x x x	x x	x 0 x	0 x	x x x	x x - x x	x x - - x	- - - - X
X X X X 	x x - - - x	x x x x x x	x x x x x	x - x	0 x - x	x x x x x	x x x	x x x x x	x x 0 x	x x x x	x x x x	x x x x	x x x x	x x x x x x	- X X X - - X X	- - - - - X X		× - - - - -	X X - - -	X	0 - 2 - 3 X X	× × × × × ×	x x - - x	- - - X	- - - X X	- - - X X X X	X X X X X	x x : x :	× > × > × >) (× × × × × × ×	x x x	x x - x	X X - - - X	- - - X X X X	x x x	x x	- x 0 x x x x	x x x x x x x	×××	x 0 x	0 x	x x x x	x x - x x x	x x x	X
X X X X X	x x x	x x x x x	x x x x x	x - x	0 x - x	x x x x x x x x x	x x x x	- : x x x x x x x x x x x x x x x x x x	x x 0 x	x x x x	x x x x	x x x x	x x x - x	x x x x x x x x x x x x x x x x x x x	- X X X - - X X	- - - - - X X		× - - - - -	X X - - -	X	0 - 2 - 3 X X	× × × × × ×	x x - - x	- - - X	- - - X X	- - X X X X	X X X X X	x x : x :	× > × > × >) (× × × × × × × ×	x x x	x x - x	x x x - - x	- - - X X X X X	x x x	x x	0 x x x	x x x x x x	x x x x	x 0 x	0 x x	x x x x x x x x x x x x x x x x x x x	x x - x x x x x	x x x x	x
X X X X 	x x x	x x x x x x	x x x x x	× - × × × ×	0 x - x	× × × × × × ×	x x x x	- : X X X X X X	x x 0 x	x x x x	x x x x	× × × × ×	× × × × × ×	x x x x x x x x x x x x x x x x x x x	- X X X - - X X	- - - - - X X		× - - - - -	X X - - -	X	0 - 2 - 3 X X	× × × × × ×	x x - - x	- - - X	- - - X X	- - - X X X X	X X X X X	x x : x :	× > × > × >) (× × × × × × × ×	x x x	x - - x 0	x x x - - x	- - - X X X X X	- X X X X X X X	x x	x 0 x x x	x x x x x x	× × × × × × × × × × × × × × × × × × ×	x 0 x	0 x x	× × × × × × × × × × × × × × × · ·	x x - x x x x -	x x x x	×
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x 0 x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	-	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x 0 x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	-	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	-	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	- - -	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	- - -	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	- - -	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	- - -	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	- - -	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	-	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	-	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	-	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	-	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	-	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	-	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	- - -	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	- - -	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	- - -	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	- - -	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	- - -	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	- - -	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x 0 x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	- - -	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x 0 x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	- - -	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 X 3 7 - 3 7 X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	- - -	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -
	0		x	X X X	x x	X X X	X X X	x		0		×	X X X	x x	- x x x x x x	- - - - X X		X X X X	x x x	x x	0 - 2 - 3 X X	X X X X X X X X X X X X X X X X X X X	x x x x 0	- - - X	- - - X X	x x x x x x x x x x x x x x x x x	x x x x x x x x x	x : x : 0	× > > > > > > > > > > > > > > > > > > >)	X X X X X X X X X X X X X X X X X X X	x x x x	× -	x -	x x -	- - -	-	-	- - -	x x -	x -	x -	x x -	X X -	X - -	× - -

Time = 300000 Number of Craters X X X	X X X X X X X X X
X	X X X X X X X X X X X X X X X X

```
Time
           Number of Craters
0
               0
10000
                         10.0
20000
                               15.0
            ******
30000
                                         25.0
40000
50000
                                            27.0
60000
70000
                                                  33.0
80000
                                                             43.0
90000
100000
110000
                                                                         54.0
120000
                                                                      51.0
130000
                                                                      51.0
140000
                                                                   49.0
150000
160000
170000
                                                                            57.0
                                                                           56.0
180000
190000
200000
                                                                              59.0
210000
                                                                               60.0
220000
                                                                             58.0
230000
                                                                           56.0
240000
                                                                            57.0
250000
                                                                              59.0
260000
                                                                            57.0
                                                                           56.0
270000
280000
                                                                            57.0
290000
                                                                               60.0
300000
                                                                            57.0
310000
                                                                             58.0
Code:
```

```
#!/usr/bin/python
import random
# area is 500km x 500 km but is broken into a 10km grid
\# therefore we can use a 50 x 50 area and have craters be 5 units large rather than 50
SIZE = 50
craterSize = SIZE/10
craters = [0]
time = 0
crater = 0.0
EMPTY = '-'
CENTER = '0'
CRATER = ' '
DEBRIS = 'x'
# initialize empty, uncratered grid
grid = [[EMPTY for x in xrange(SIZE)] for x in xrange(SIZE)]
# function that goes through the grid and counts the number of crater centers
def numCraters(grid):
    crater = 0
    for i in range(SIZE-1):
        for j in range(SIZE-1):
            if(grid[i][j] == CENTER):
```

```
crater += 1.0 return crater
```

```
# Randomly pick a spot on the grid and make a crater centering at this location.
def makeImpact(grid):
    imp_i = random.randrange(0, SIZE-1)
    imp_j = random.randrange(0, SIZE-1)
    for i in range((craterSize/2)+2):
        for j in range(((craterSize/2)+2)-i/2):
            # must ensure that you won't write outside of the grid, if the center is near
an edge of the grid
            # create circle of debris first, as this is the largest circle
            if(imp_i+i >= SIZE):
                if(imp_j+j >= SIZE):
                    grid[imp_i][imp_j-j] = DEBRIS
                    grid[imp_i-i][imp_j-j] = DEBRIS
                    grid[imp_i-i][imp_j] = DEBRIS
                if(imp_j-j \le 0):
                    qrid[imp_i][imp_j+j] = DEBRIS
                    grid[imp_i-i][imp_j] = DEBRIS
                    grid[imp_i-i][imp_j+j] = DEBRIS
                if(imp_j+j < SIZE and imp_j-j > 0):
                    if(imp_j+j >= SIZE): print SIZE
                    grid[imp_i][imp_j-j] = DEBRIS
                    grid[imp_i][imp_j+j] = DEBRIS
                    grid[imp_i-i][imp_j-j] = DEBRIS
                    grid[imp_i-i][imp_j+j] = DEBRIS
            if(imp_i - i < 0):
                if(imp i+i >= SIZE):
                    grid[imp_i][imp_j-j] = DEBRIS
                    grid[imp_i+i][imp_j-j] = DEBRIS
                    grid[imp_i+i][imp_j] = DEBRIS
                if(imp_j-j < 0):
                    grid[imp_i][imp_j+j] = DEBRIS
                    grid[imp_i+i][imp_j] = DEBRIS
                    grid[imp_i+i][imp_j+j] = DEBRIS
                if(imp_j+j < SIZE and imp_j-j>0):
                    if(imp_j+j >= SIZE): print SIZE
                    grid[imp_i][imp_j-j] = DEBRIS
                    grid[imp_i][imp_j+j] = DEBRIS
                    grid[imp_i+i][imp_j-j] = DEBRIS
                    grid[imp_i+i][imp_j+j] = DEBRIS
            if(imp_j+j >= SIZE):
                if(imp_i+i >= SIZE):
                    grid[imp_i-i][imp_j] = DEBRIS
                    grid[imp_i-i][imp_j-j] = DEBRIS
                    grid[imp_i][imp_j-j] = DEBRIS
                if(imp_i-i \le 0):
                    grid[imp_i-i][imp_j] = DEBRIS
                    grid[imp_i-i][imp_j-j] = DEBRIS
                    grid[imp_i][imp_j-j] = DEBRIS
                if((imp_i+i < SIZE) and imp_i-i > 0):
                    grid[imp_i-i][imp_j] = DEBRIS
                    grid[imp_i+i][imp_j] = DEBRIS
                    grid[imp_i-i][imp_j-j] = DEBRIS
                    grid[imp_i+i][imp_j-j] = DEBRIS
```

```
if(imp_j-j \le 0):
            if(imp_i+i >= SIZE):
                grid[imp_i-i][imp_j] = DEBRIS
                grid[imp_i-i][imp_j+j] = DEBRIS
                grid[imp_i][imp_j+j] = DEBRIS
            if(imp_i-i \le 0):
                grid[imp_i-i][imp_j] = DEBRIS
                grid[imp_i-i][imp_j+j] = DEBRIS
                grid[imp_i][imp_j+j] = DEBRIS
            if(imp_i+i < SIZE and imp_i-i>0):
                grid[imp_i-i][imp_j] = DEBRIS
                grid[imp_i+i][imp_j] = DEBRIS
                grid[imp_i-i][imp_j+j] = DEBRIS
                grid[imp_i+i][imp_j+j] = DEBRIS
        if(imp_j+j < SIZE  and imp_j-j >= 0  and imp_i +i < SIZE  and imp_i -i >= 0):
            grid[imp_i-i][imp_j-j] = DEBRIS
            grid[imp_i+i][imp_j-j] = DEBRIS
            grid[imp_i-i][imp_j +j] = DEBRIS
            grid[imp_i+i][imp_j +j] = DEBRIS
# make a smaller circle within the debris circle for the actual crater
for i in range((craterSize/2)+1):
    for j in range(((craterSize/2)+1)-i/2):
        if(imp_i+i >= SIZE):
            if(imp_j+j >= SIZE):
                grid[imp_i][imp_j-j] = CRATER
                grid[imp_i-i][imp_j-j] = CRATER
                grid[imp_i-i][imp_j] = CRATER
            if(imp_j-j \le 0):
                grid[imp_i][imp_j+j] = CRATER
                grid[imp_i-i][imp_j] = CRATER
                grid[imp_i-i][imp_j+j] = CRATER
            if(imp_j+j < SIZE and imp_j-j>0):
                grid[imp_i][imp_j-j] = CRATER
                grid[imp_i][imp_j+j] = CRATER
                grid[imp_i-i][imp_j-j] = CRATER
                grid[imp_i-i][imp_j+j] = CRATER
        if(imp_i - i < 0):
            if(imp_j+j >= SIZE):
                grid[imp_i][imp_j-j] = CRATER
                grid[imp_i+i][imp_j-j] = CRATER
                grid[imp_i+i][imp_j] = CRATER
            if(imp_j-j-j < 0):
                grid[imp_i][imp_j+j] = CRATER
                grid[imp_i+i][imp_j] = CRATER
                grid[imp_i+i][imp_j+j] = CRATER
            if(imp_j+j < SIZE and imp_j-j>0):
                grid[imp_i][imp_j-j] = CRATER
                grid[imp_i][imp_j+j] = CRATER
                grid[imp_i+i][imp_j-j] = CRATER
                grid[imp_i+i][imp_j+j] = CRATER
        if(imp_j+j >= SIZE):
            if(imp_i+i >= SIZE):
                grid[imp_i-i][imp_j] = CRATER
                grid[imp_i-i][imp_j-j] = CRATER
                grid[imp_i][imp_j-j] = CRATER
            if(imp_i-i \le 0):
                grid[imp_i-i][imp_j] = CRATER
                grid[imp_i-i][imp_j-j] = CRATER
```

```
grid[imp_i][imp_j-j] = CRATER
                if((imp_i+i < SIZE) and imp_i-i > 0):
                    grid[imp_i-i][imp_j] = CRATER
                    grid[imp_i+i][imp_j] = CRATER
                    grid[imp_i-i][imp_j-j] = CRATER
                    grid[imp_i+i][imp_j-j] = CRATER
            if(imp_j-j-j \le 0):
                if(imp_i+i >= SIZE):
                    grid[imp_i-i][imp_j] = CRATER
                    grid[imp_i-i][imp_j+j] = CRATER
                    grid[imp_i][imp_j+j] = CRATER
                if(imp_i-i \le 0):
                    grid[imp_i-i][imp_j] = CRATER
                    grid[imp_i-i][imp_j+j] = CRATER
                    grid[imp_i][imp_j+j] = CRATER
                if(imp_i+i < SIZE and imp_i-i>0):
                    grid[imp_i-i][imp_j] = CRATER
                    grid[imp_i+i][imp_j] = CRATER
                    grid[imp_i-i][imp_j+j] = CRATER
                    grid[imp_i+i][imp_j+j] = CRATER
            if(imp_j+j < SIZE  and imp_j-j >= 0  and imp_i + i < SIZE  and imp_i - i >= 0):
                grid[imp_i-i][imp_j-j] = CRATER
                grid[imp_i+i][imp_j-j] = CRATER
                grid[imp_i-i][imp_j +j] = CRATER
                grid[imp_i+i][imp_j +j] = CRATER
        grid[imp_i][imp_j] = CENTER #finally place the center at the center of the
impact
    return grid
#returns true if there is saturation (ie less that 5% change when time doubles)
def checkSat(craters, time):
    if(time==0):
        curAvg = 0.0
        oldAvg = 0.0
    else:
        if((time/2)==0):
            curAvg = craters[time] / time
            oldAvg = 0.0
        else:
            curAvg = craters[time] / time
            oldAvg = craters[time/2] / (time/2)
    # if the number of craters changes by less than 5% when time is doubled
    # we have reached saturation
    if(abs(craters[time] - craters[time/2]) < craters[time/2]*0.05):</pre>
        # if there are less than 5 craters we definitely have not reached saturation
        # but test could still pass
        if(craters[time] < 5):</pre>
            return False
        else:
            return True
    else:
        return False
# while the grid is not saturated with craters continue randomly generating impacts and
increasing time
while not checkSat(craters, time):
```

```
# cratering rate is 1 impact every 1000 years, therefore every year chance of impact
is 1/1000
   # generate a number between 1 and 1000
   impact = random.randrange(1,1000)
   # if the random number is some specific number make an impact
   if(impact == 129):
       grid = makeImpact(grid)
   craters.append(numCraters(grid))
   if(time \% 30000 == 0):
       print "\nTime = ", time, " Number of Craters= ", craters[time]
       for x in grid:
          print(' '.join(x))
   time += 1
print "\n-----
results-----"
for x in grid:
   print(' '.join(x))
print "Number of Craters: ", numCraters(grid)
print "Years to Saturation: ", time
print "Time | Number of Craters"
for i in range(len(craters)):
  if(i \% 10000 == 0):
       toprint = ""
       for x in range(int(craters[i])):
          toprint += "*"
       print i, " | ", toprint, " ", craters[i]
```

We are wanting to simulate a 500km x 500km area but we have divided it into 10km cells meaning we can do a simulation for a 50x50 area instead, which will run more quickly. Each year there is a 1/1000 chance an impact will occur. As long as we have not reached saturation, meaning the number of craters has changed by less than 5% when the time doubles, we continue allowing impacts to form.