New version of the numerical experiments of the paper: "Optimizing the Packing of Cylinders into a Rectangular Container: A Nonlinear Approach, *European Journal of Operational Research* 160, pp. 19–33, 2005".

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Abstract

This experiments correspond to the experiments of [2]. They were rerun on August 23^{th}, 2005 with a new version o the otimization solver GENCAN (see the TANGO Project web page: http://www.ime.usp.br/-∼egbirgin/tango/). Basically, the same results of [2] were obtained, unless in problem 1.9 for which one more item was packed. This text describes the new numerical experiments which follows closely the numerical experiments of [1].

Key words: Cylinder packing, rectangular container, circular container, nonlinear programming, bound-constrained minimization, convex-constrained minimization.

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1 Numerical experiments

Table 1 shows the description of each problem (rectangular objects dimensions, circular items ratios and their areas). The first 3 problems were taken from [4] and the other 45 were taken from [3].

All the experiments were run on an 1.8GHz AMD Opteron 244 processor, 2Gb of RAM memory and Linux operating system. Codes are in Fortran77 and the compiler option "-O4" was adopted.

In the experiments we set our maximum effort in terms of CPU time fixing $T = 6$ hours. We set $m_{\rm lb} = 0$ and $m_{\rm ub}$ as the upper bound based on the object and the items areas showed in Table 1. Table 2 shows, for each problem, the number of circles that were packed in [4, 3] and the number of circles that were packed in this study. Table 2 also shows the total number of nonlinear programming problems that were solved and the elapsed CPU time until the best solution was found. (The remaining time, to complete the 6 hours, was spent just to confirm that a better solution could not be found.) Figures 1–48 illustrate the solutions.

See [2, 1] for details.

Problem	Rectangular object		Circular Item	
	$L \times W$	Area	Ratio	Area
1	1200 × 800	960000	102	32685.10
2	1200 × 800	960000	101	32047.36
3	471 × 196	92316	14	615.75
1.1	160 × 80	12800	6	113.10
1.2	100 × 200	20000	8	201.06
1.3	120 × 240	28800	10	314.16
1.4	100 × 80	8000	5	78.54
1.5	120 × 80	9600	6	113.10
1.6	120 × 100	12000	6	113.10
1.7	80 × 80	6400	5	78.54
1.8	100 × 100	10000	6	113.10
1.9	120 × 120	14400	7	153.94
2.1	160 × 80	12800	10	314.16
2.2	100 × 200	20000	13	530.93
2.3	120 × 240	28800	15	706.86
2.4	100 × 80	8000	8	201.06
2.5	120 × 80	9600	9	254.47
2.6	120 × 100	12000	10	314.16
2.7	80 × 80	6400	7	153.94
2.8	100 × 100	10000	9	254.47
2.9	120 × 120	14400	11	380.13
3.1	160 × 80	12800	14	615.75
3.2	100 × 200	20000	18	1017.88
3.3	120 × 240	28800	21	1385.44
3.4	100 × 80	8000	11	380.13
3.5	120 × 80	9600	12	452.39
3.6	120 × 100	12000	14	615.75
3.7	80 × 80	6400	10	314.16
3.8	100 × 100	10000	13	530.93
3.9	120 × 120	14400	15	706.86
4.1	160 × 80	12800	20	1256.64
4.2	100 × 200	20000	25	1963.49
4.3	120 × 240	28800	30	2827.43
4.4	100 × 80	8000	16	804.25
4.5	120 × 80	9600	17	907.92
4.6	120 × 100	12000	20	1256.64
4.7	80 × 80	6400	14	615.75
4.8	100 × 100	10000	18	1017.88
4.9	120 × 120	14400	21	1385.44
5.1	160 × 80	12800	25	1963.49
5.2	100 × 200	20000	31	3019.07
5.3	120 × 240	28800	37	4300.84
5.4	100 × 80	8000	19	1134.11
5.5	120 × 80	9600	21	1385.44
5.6	120 × 100	12000	24	1809.56
5.7	80 × 80	6400	17	907.92
5.8	100 × 100	10000	22	1520.53
5.9	120 × 120	14400	26	2123.71

Table 1: Problems definition.

Problem	Upper bound	Number of packed rectangles		Effort measurements	
		In [4, 3]	In this study	Number of trials	CPU time in seconds
1	29	22	22	25	0.06
2	29	23	23	32	0.11
3	149	124	**126**	1700	709.75
1.1	113	90	**91**	102	18.37
1.2	99	84	84	4304	419.13
1.3	91	73	**74**	2723	264.67
1.4	101	86	86	27987	2705.71
1.5	84	68	68	358	44.75
1.6	106	87	87	864	139.18
1.7	81	68	68	16794	914.48
1.8	88	70	**71**	96	6.53
1.9	93	73	**75**	126	17.24
2.1	40	32	32	37	0.22
2.2	37	29	29	36	0.15
2.3	40	32	32	33	0.22
2.4	39	32	32	2016	19.19
2.5	37	28	**30**	181	1.69
2.6	38	30	30	36	0.19
2.7	41	32	32	40	0.34
2.8	39	30	30	33	0.12
2.9	37	29	**30**	33	0.20
3.1	20	15	15	16	0.01
3.2	19	15	15	26	0.05
3.3	20	15	15	19	0.02
3.4	21	16	16	30	0.04
3.5	21	15	15	19	0.01
3.6	19	14	14	17	0.01
3.7	20	16	16	19	0.02
3.8	18	13	13	16	0.01
3.9	20	16	16	19	0.02
4.1	10	8	8	10	0.02
4.2	10	8	8	10	0.04
4.3	10	8	8	10	0.11
4.4	9	6	6	7	0.00
4.5	10	7	7	17	0.01
4.6	9	6	6	9	0.00
4.7	10	6	6	7	0.00
4.8	9	6	6	10	0.00
4.9	10	6	6	7	0.00
5.1	6	3	3	5	0.00
5.2	6	3	3	4	0.00
5.3	6	3	3	5	0.00
5.4	7	4	4	5	0.00
5.5	6	4	4	7	0.00
5.6	6	4	4	5	0.00
5.7	7	4	4	5	0.00
5.8	6	4	4	5	0.00
5.9	6	4	4	5	0.00

Table 2: Performance of the nonlinear packing procedure.

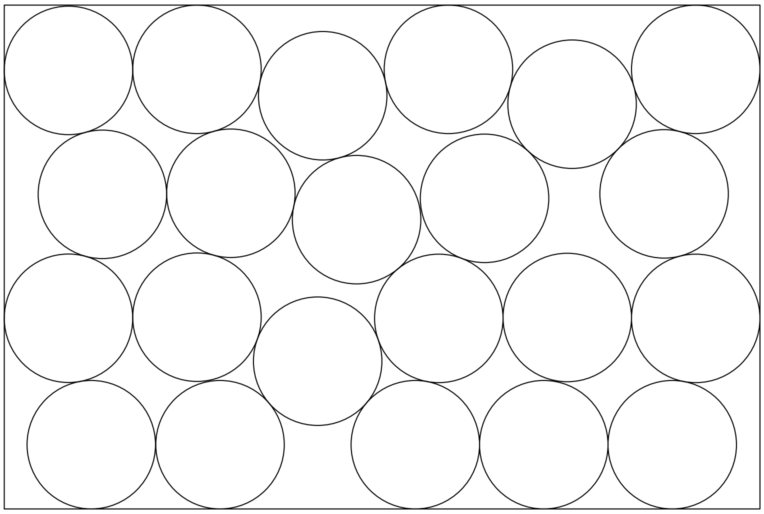


Figure 1: Problem 1.

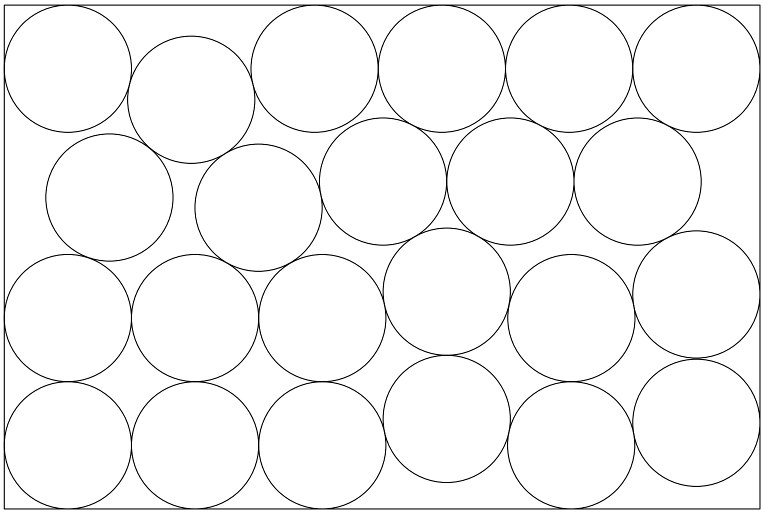
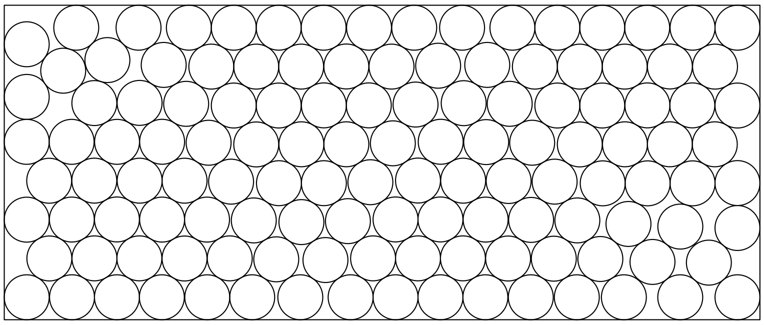


Figure 2: Problem 2.



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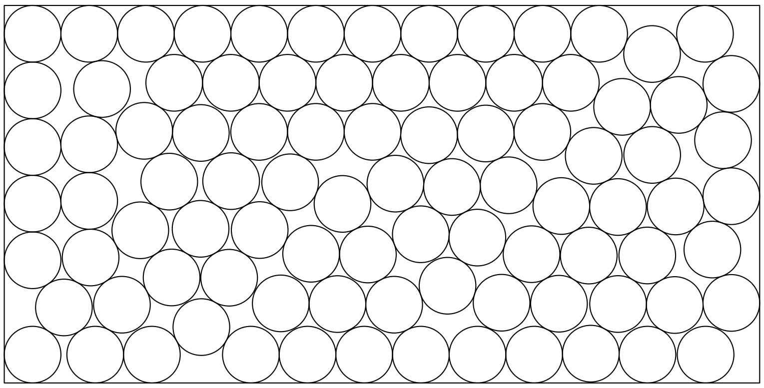

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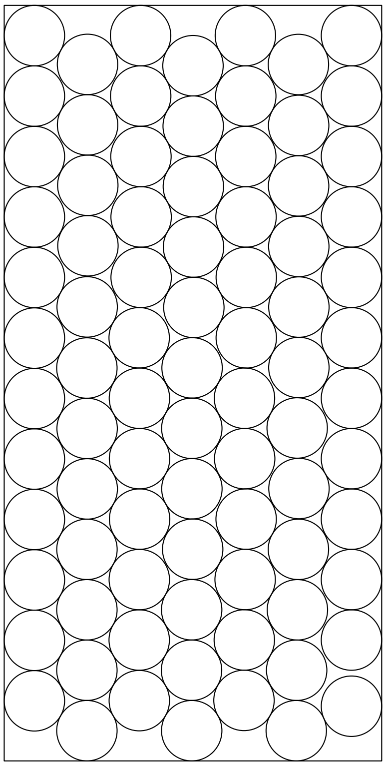

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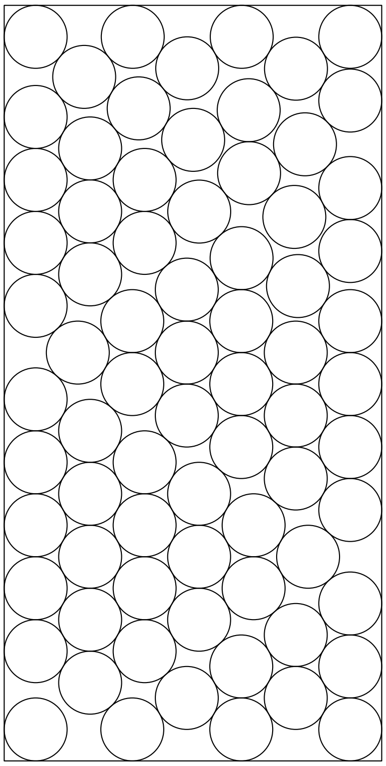

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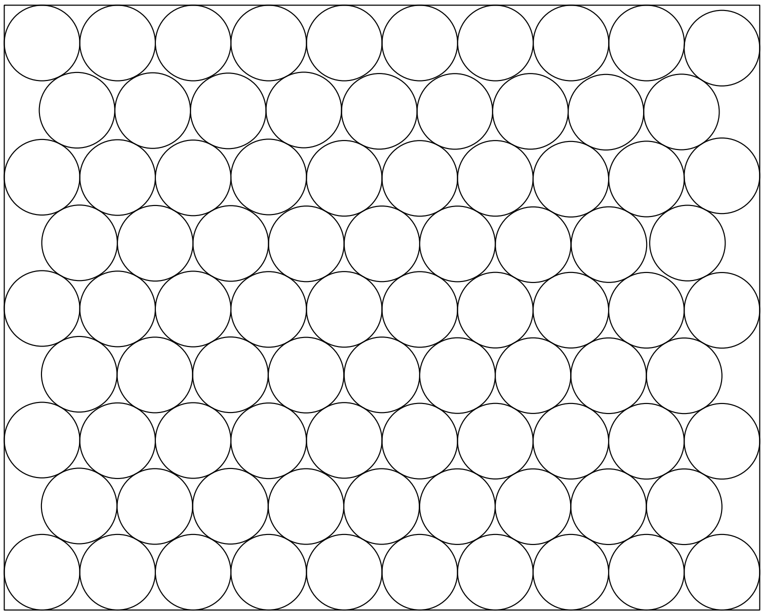

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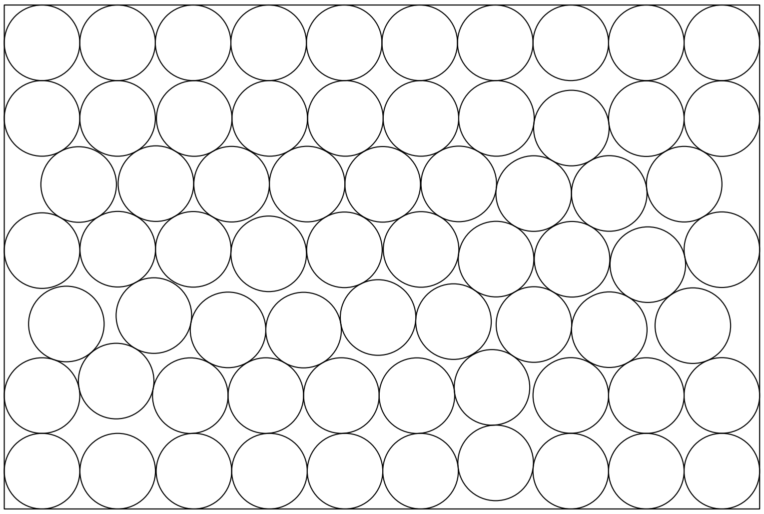

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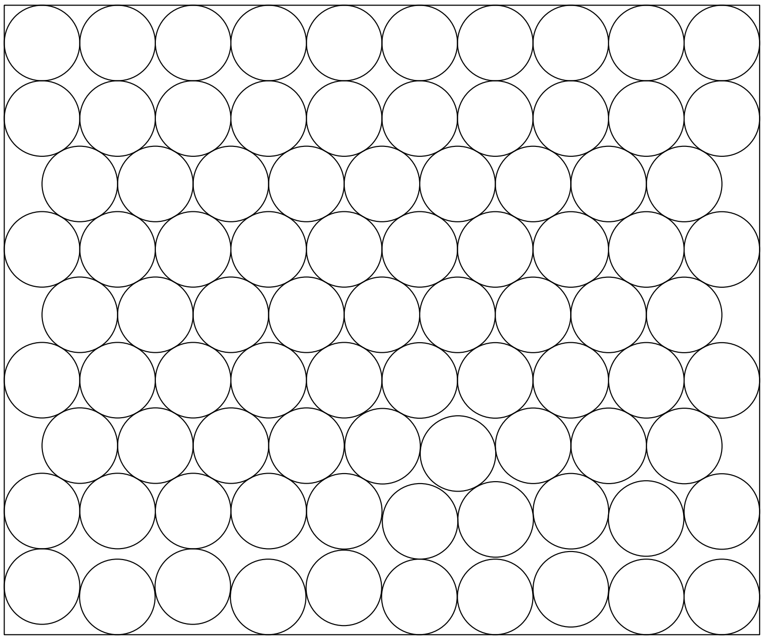

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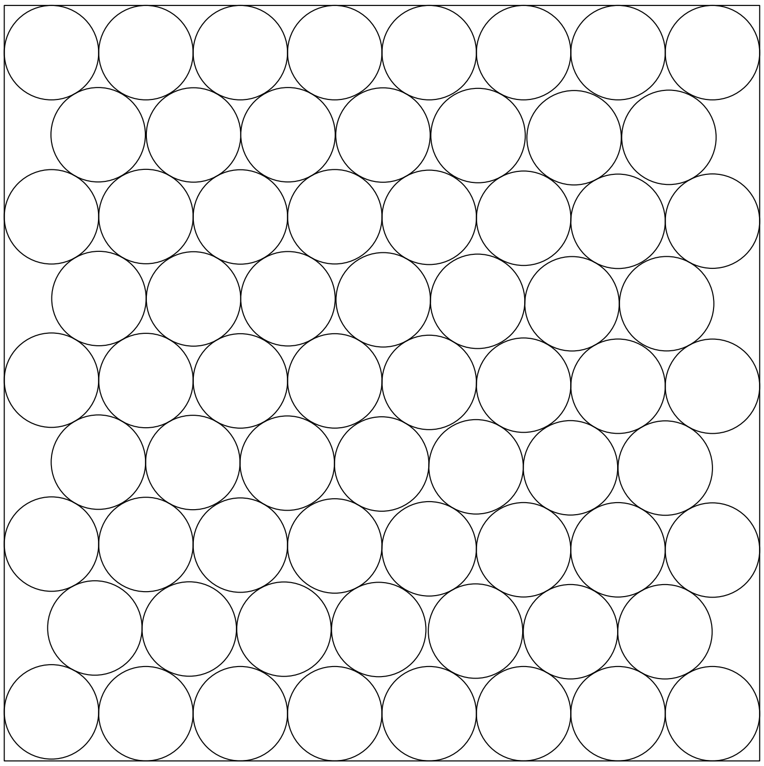

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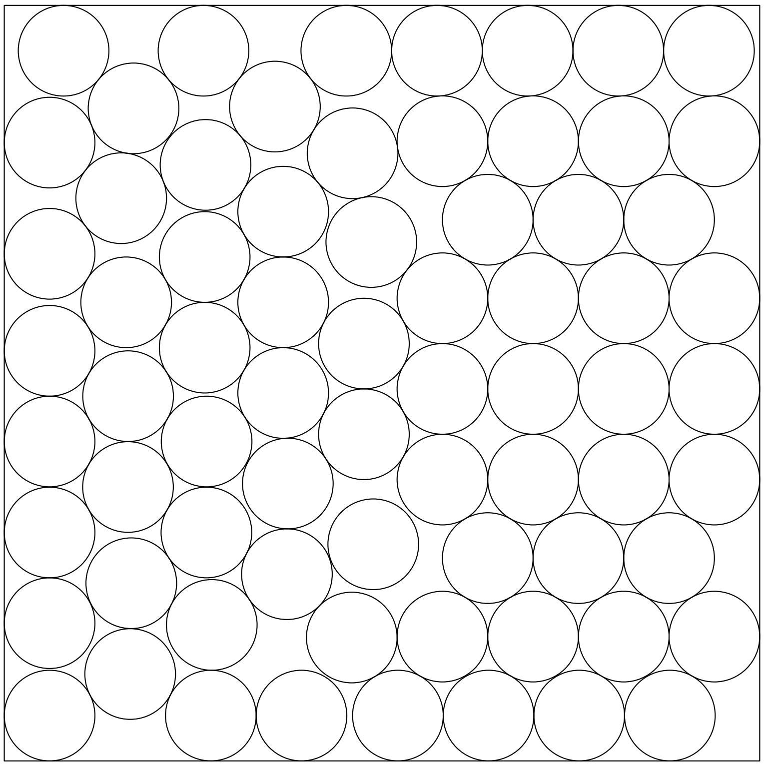

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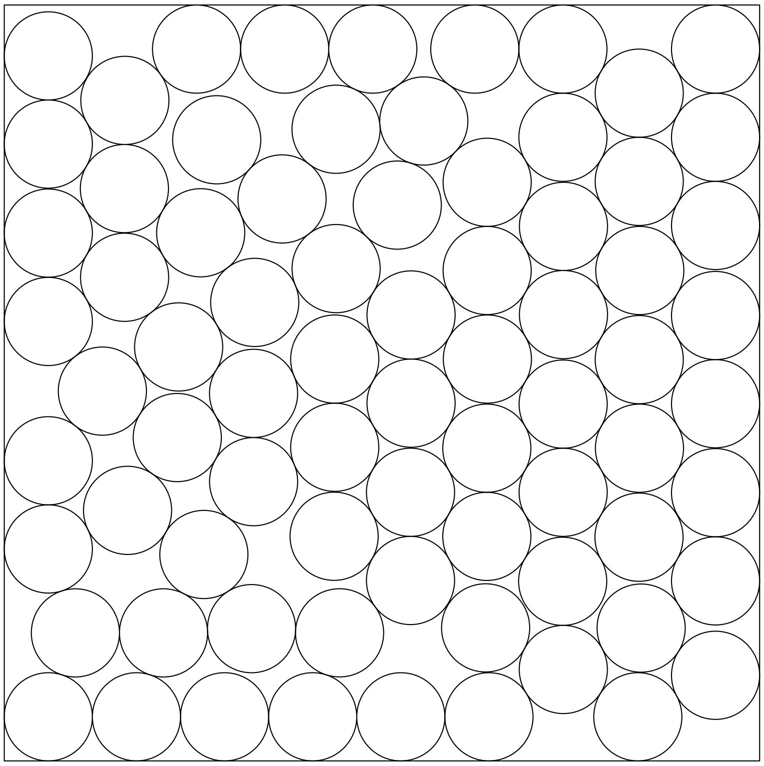

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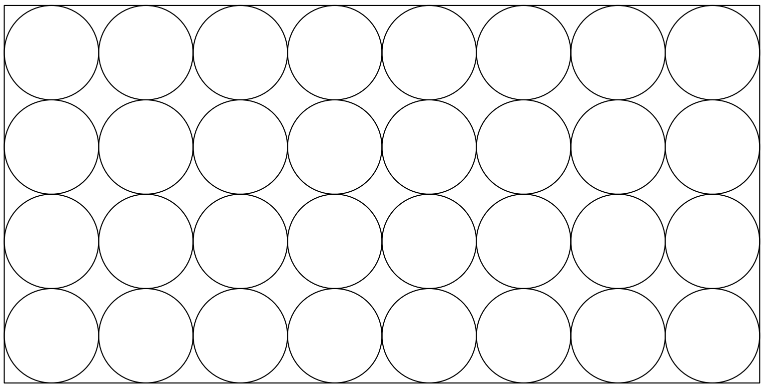

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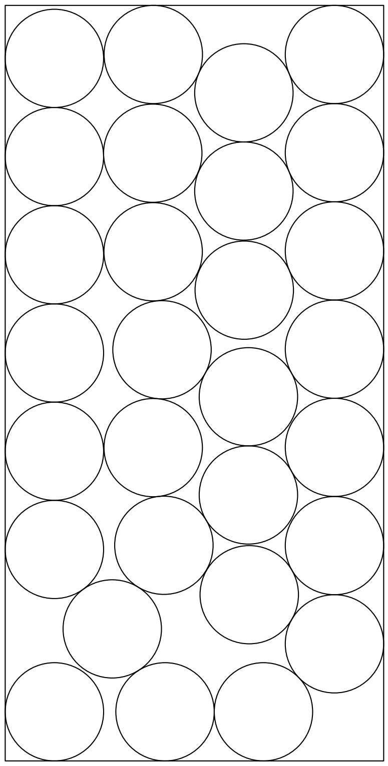

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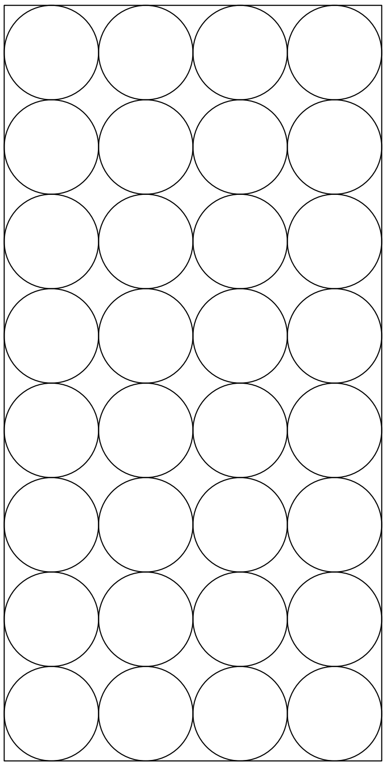

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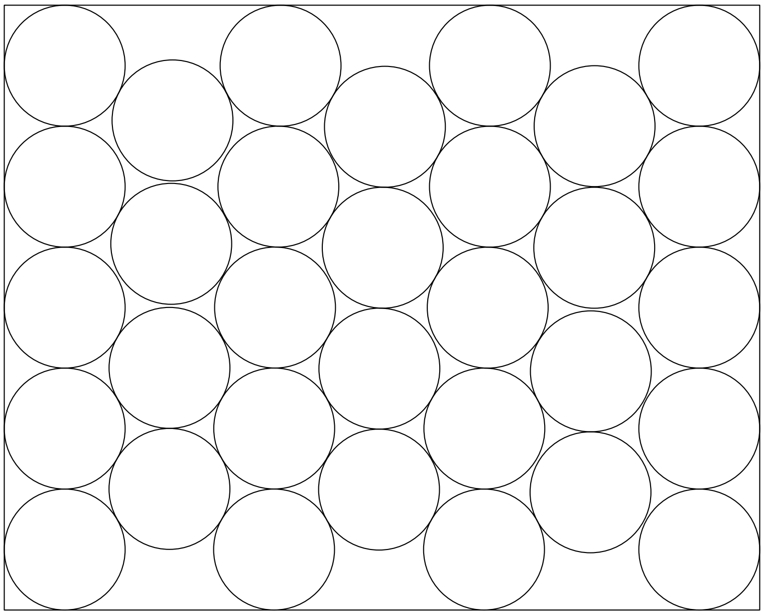

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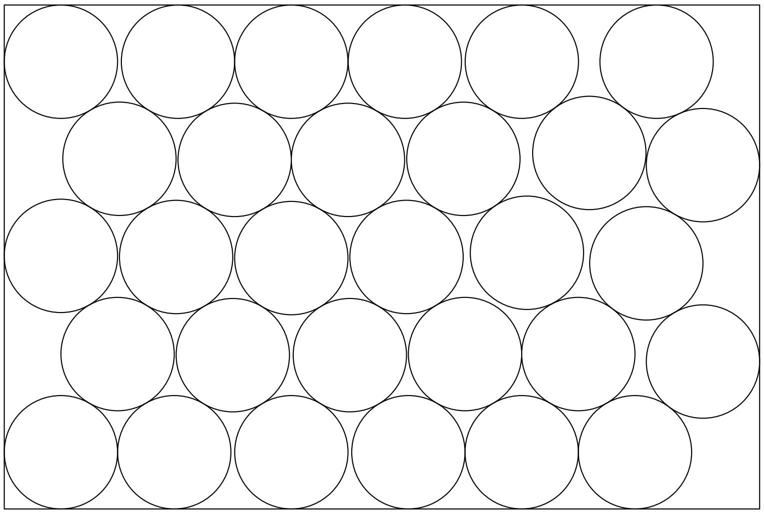

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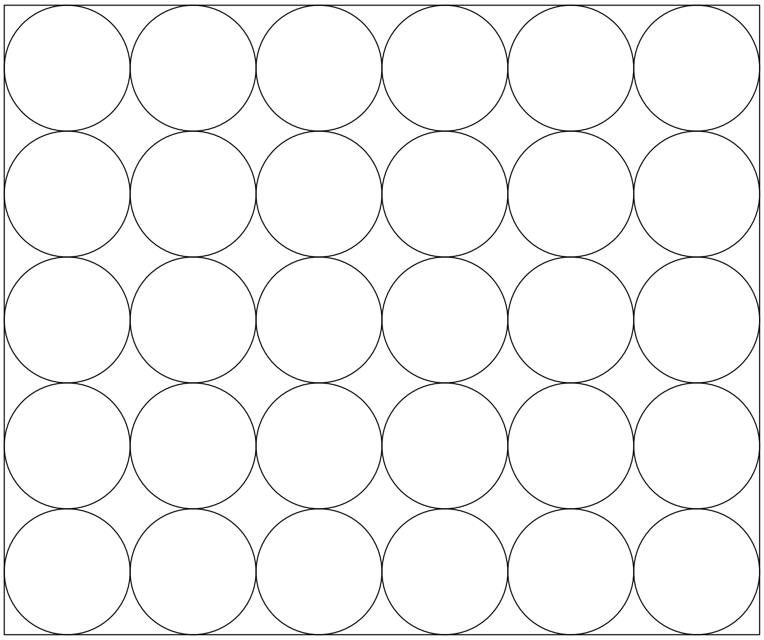

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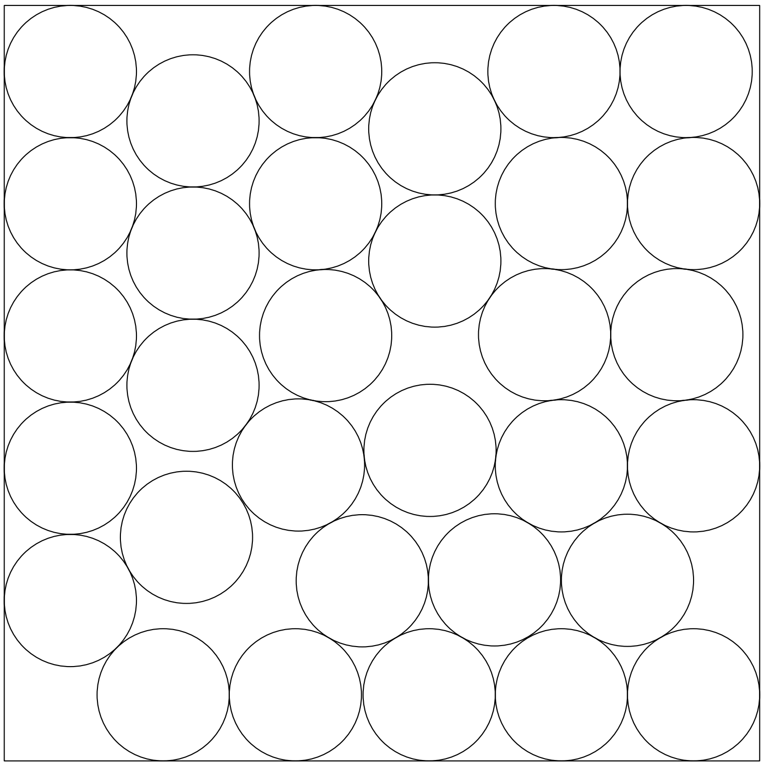

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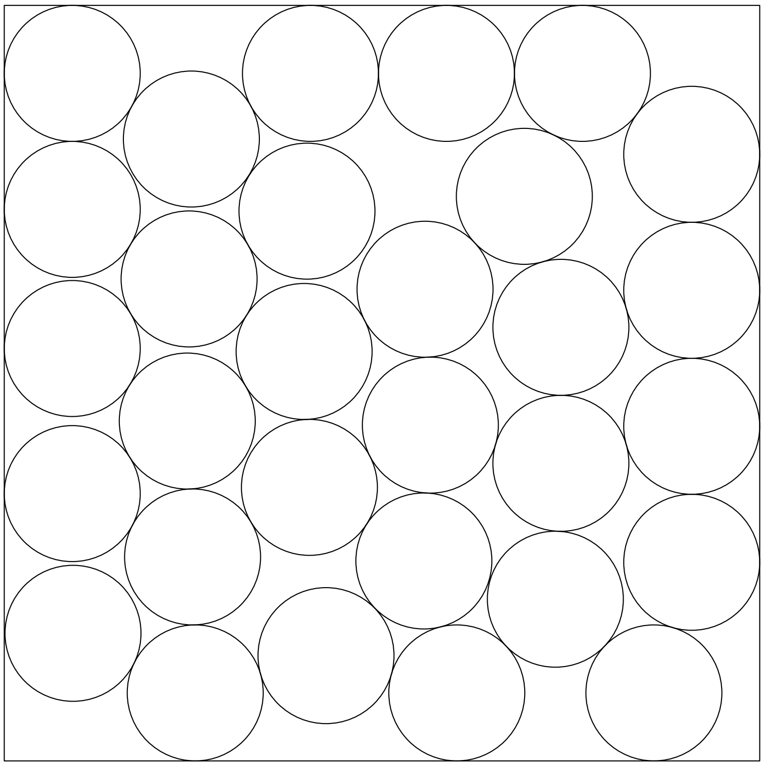

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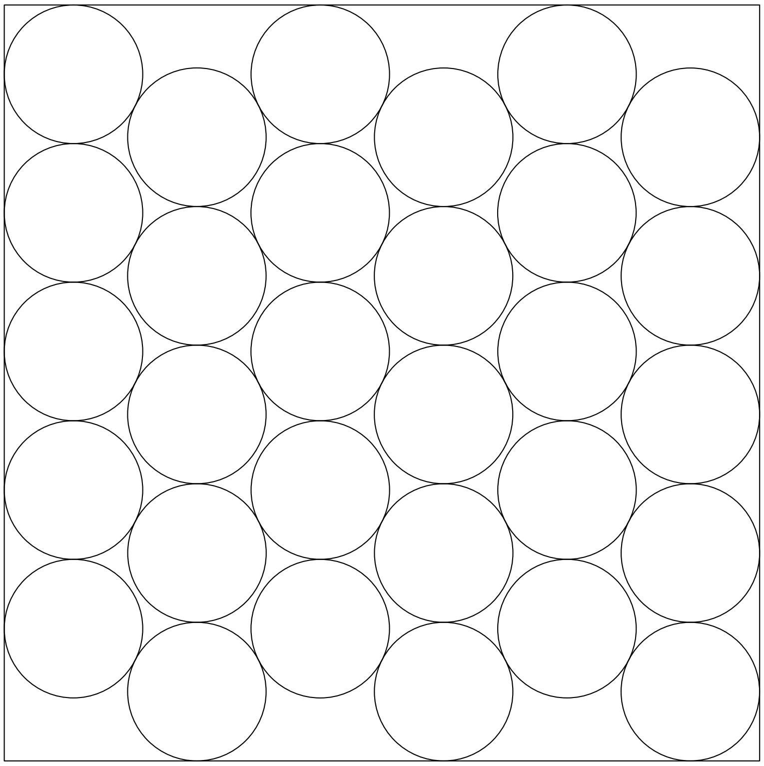

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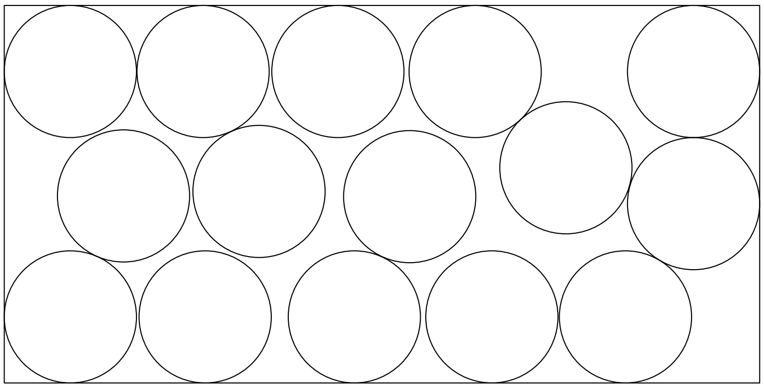

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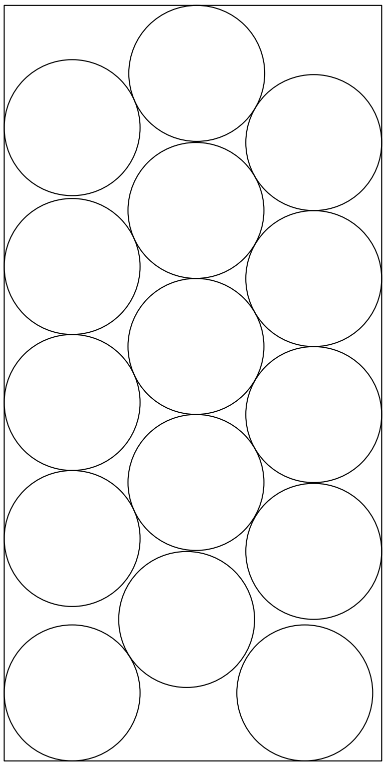

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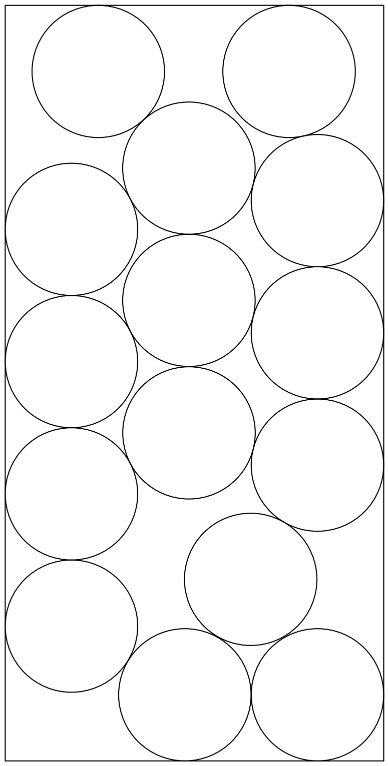

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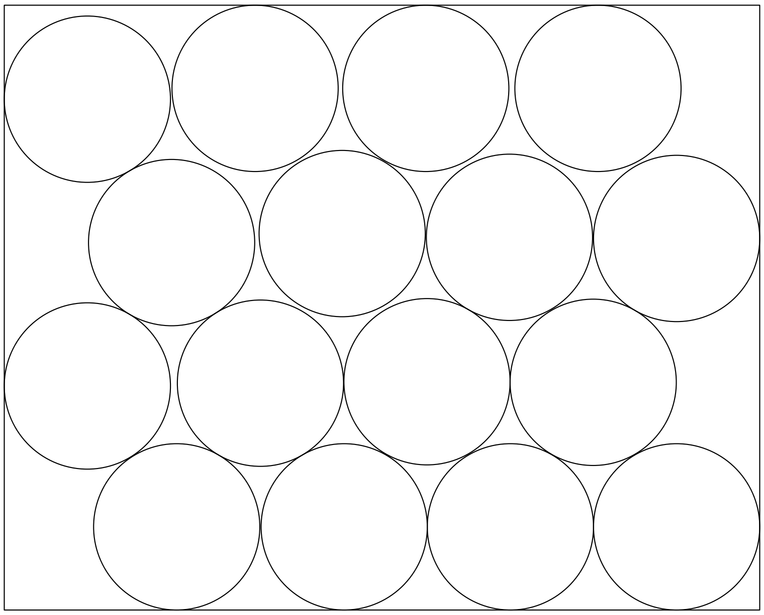

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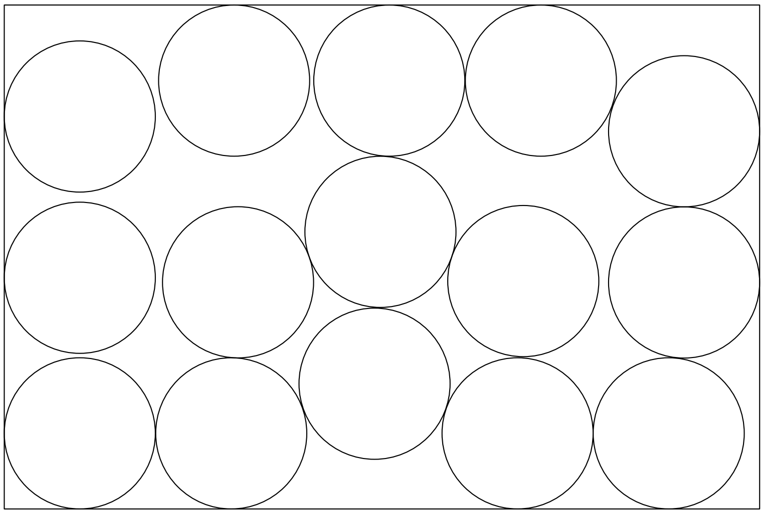

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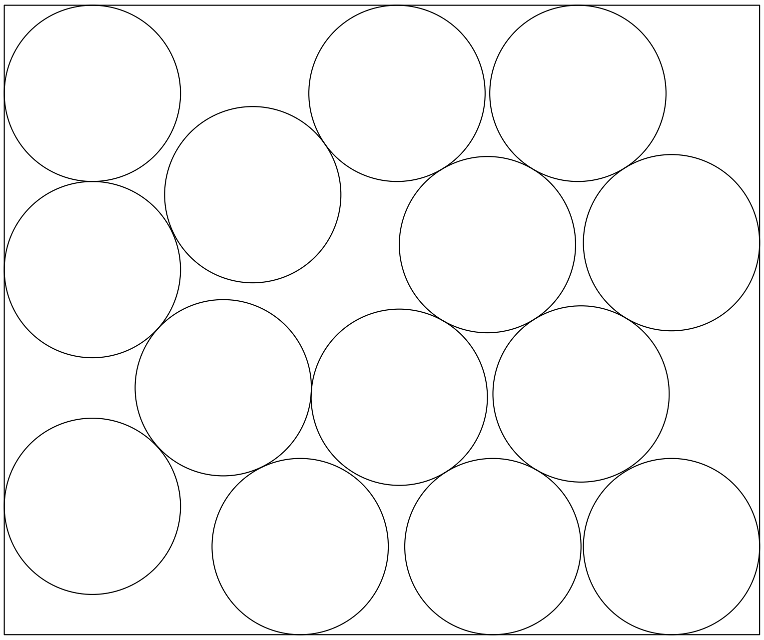

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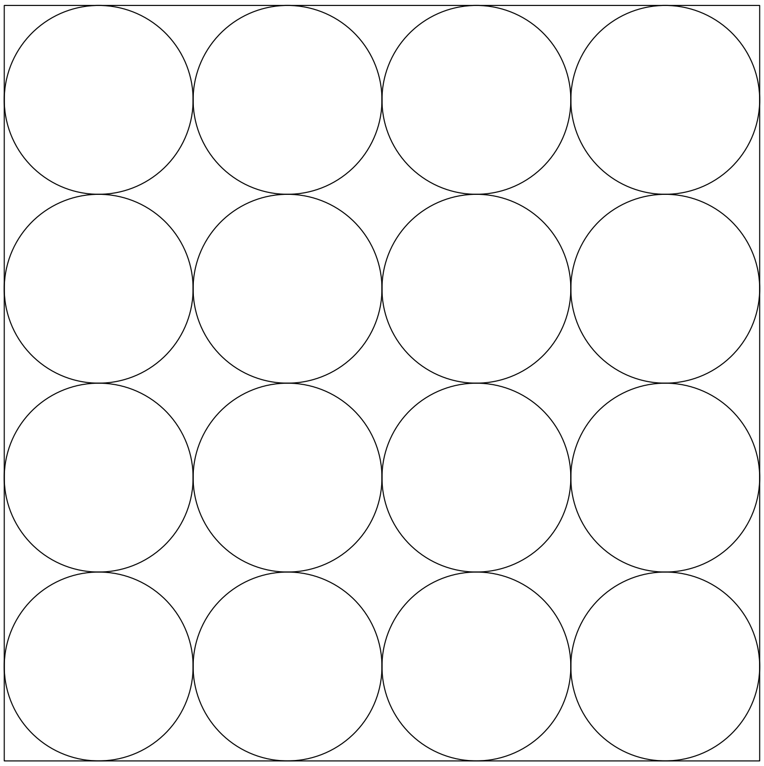

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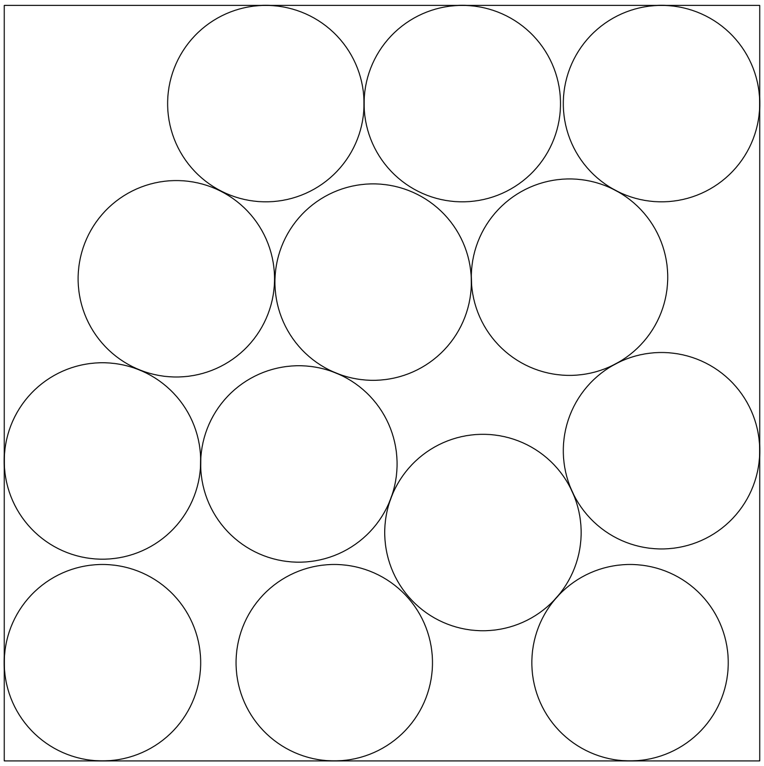

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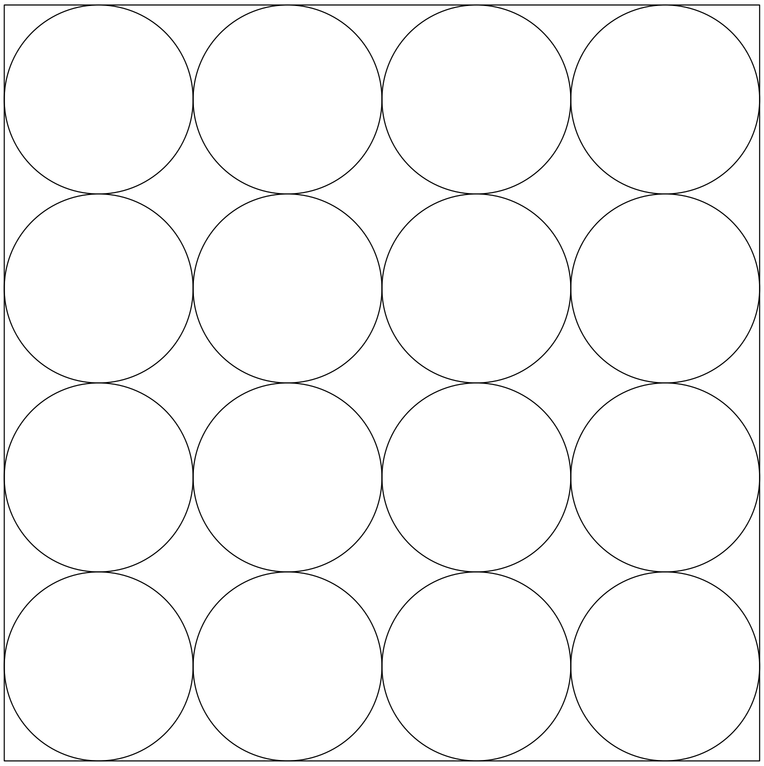

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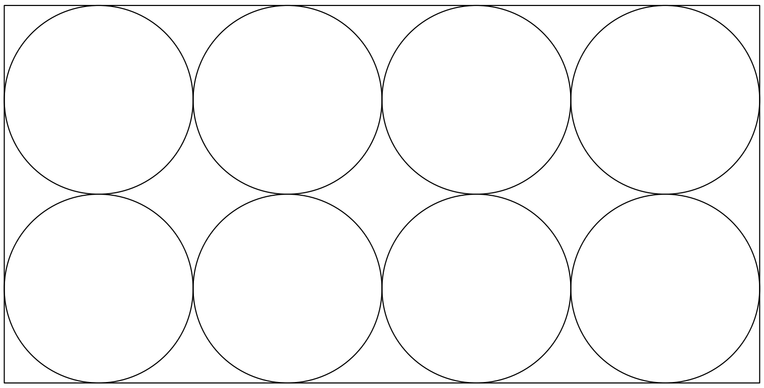

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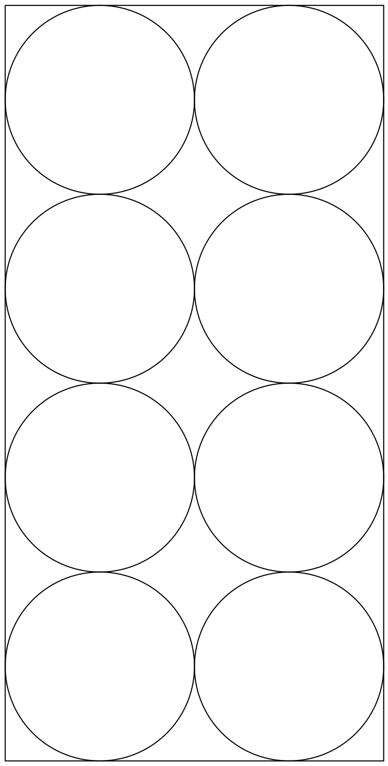

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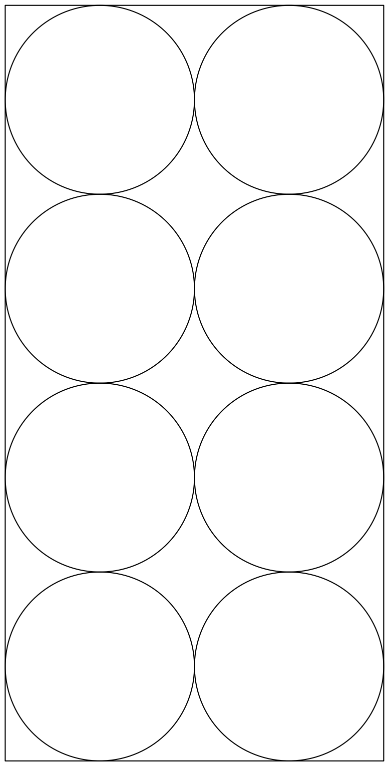

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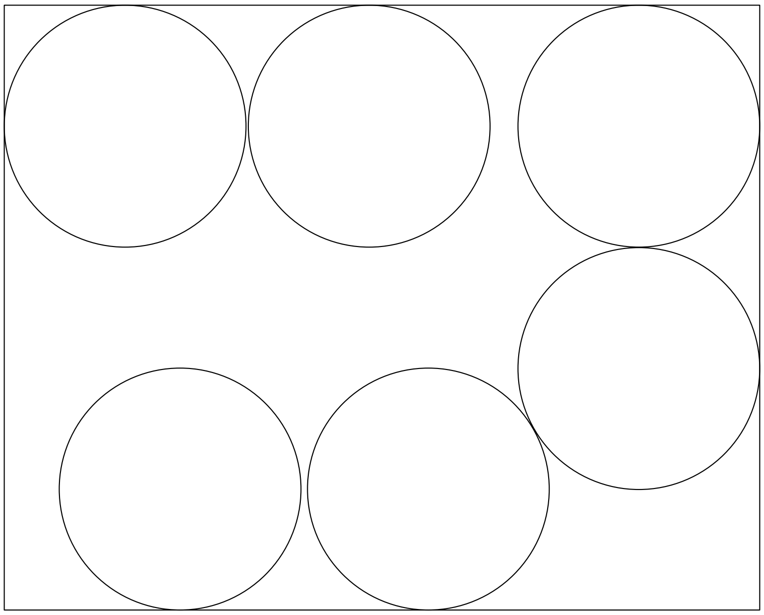

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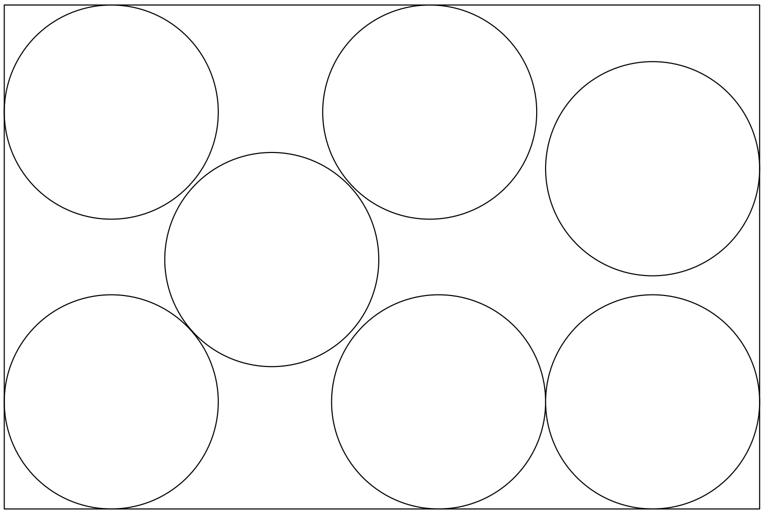

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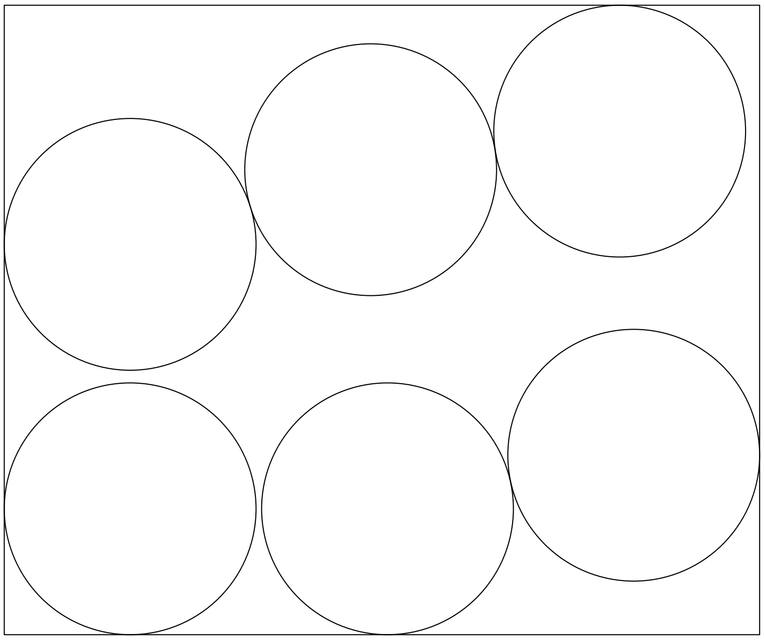

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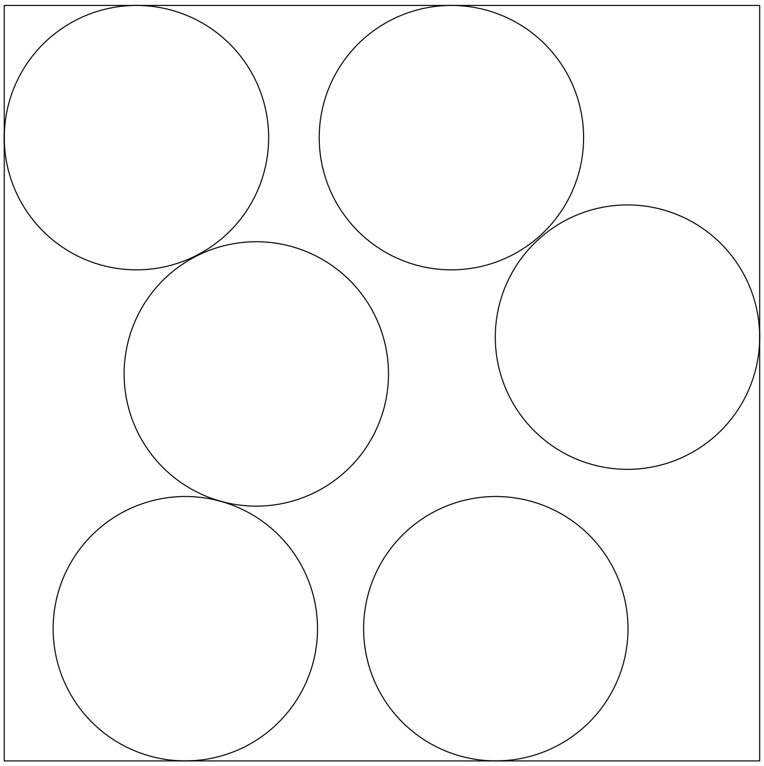

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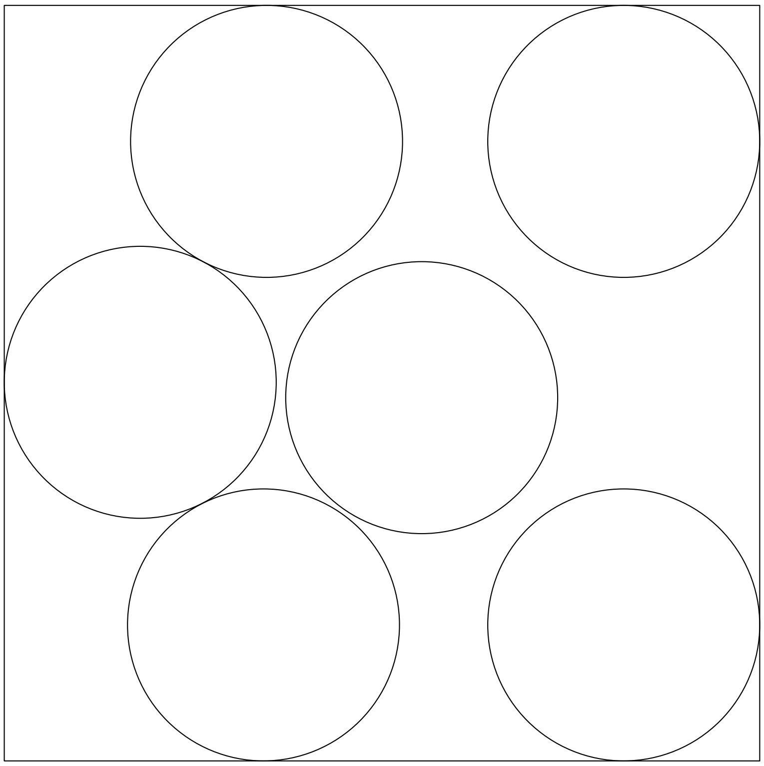

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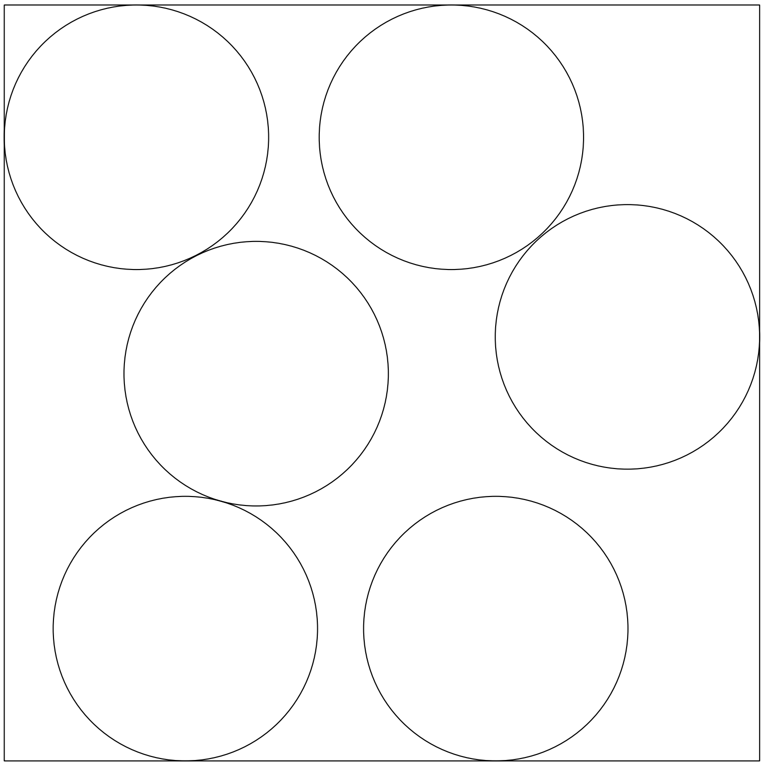

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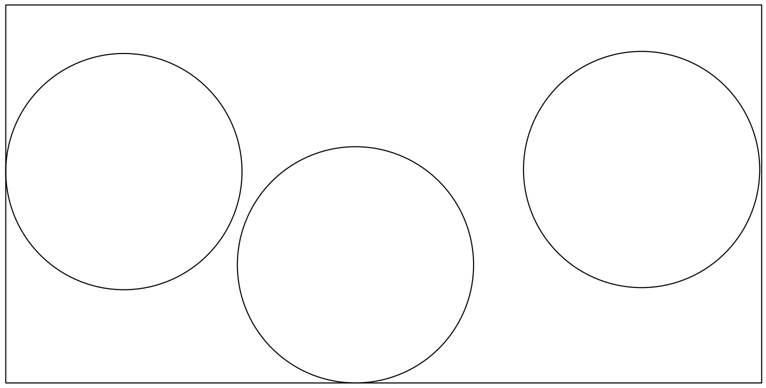

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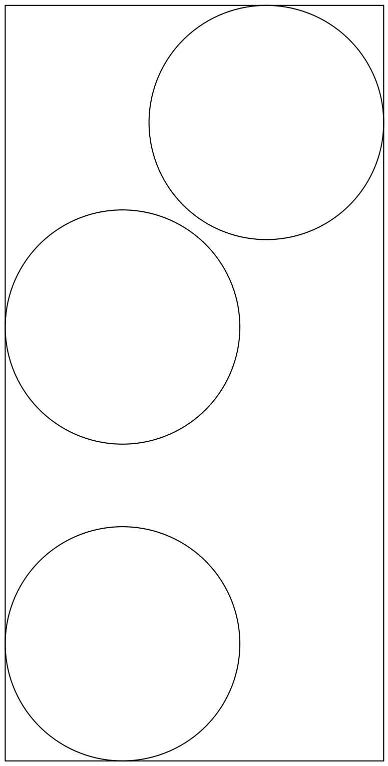

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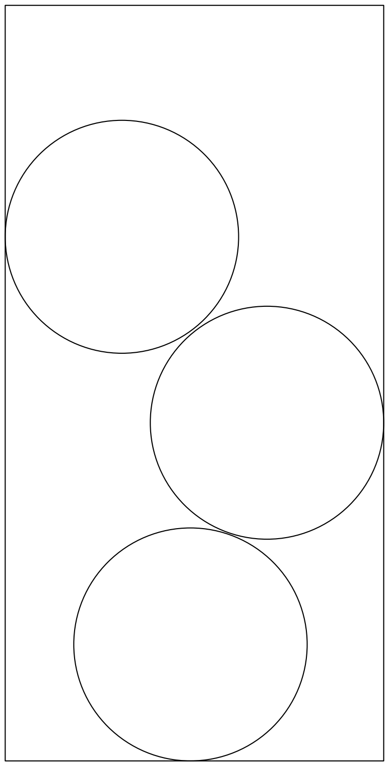

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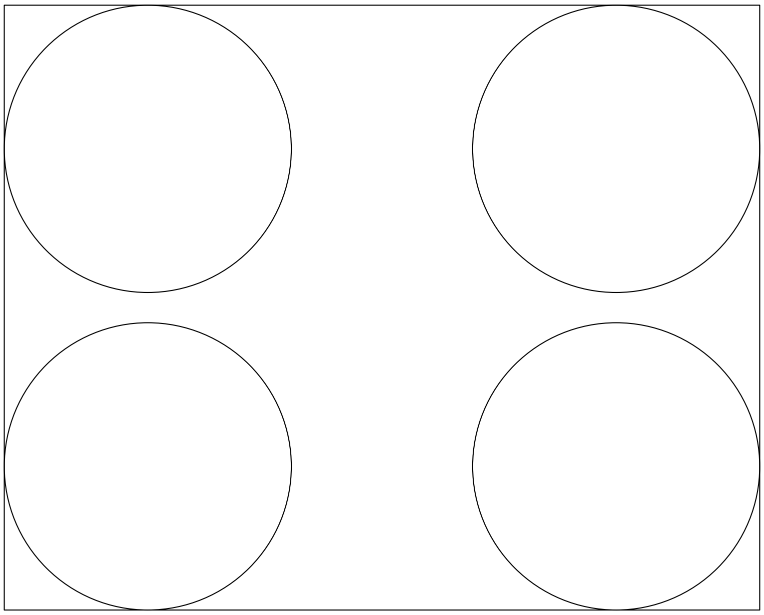

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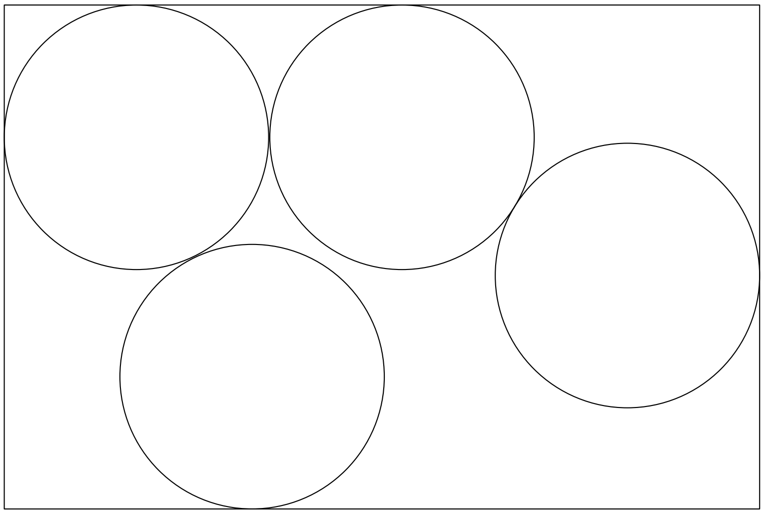

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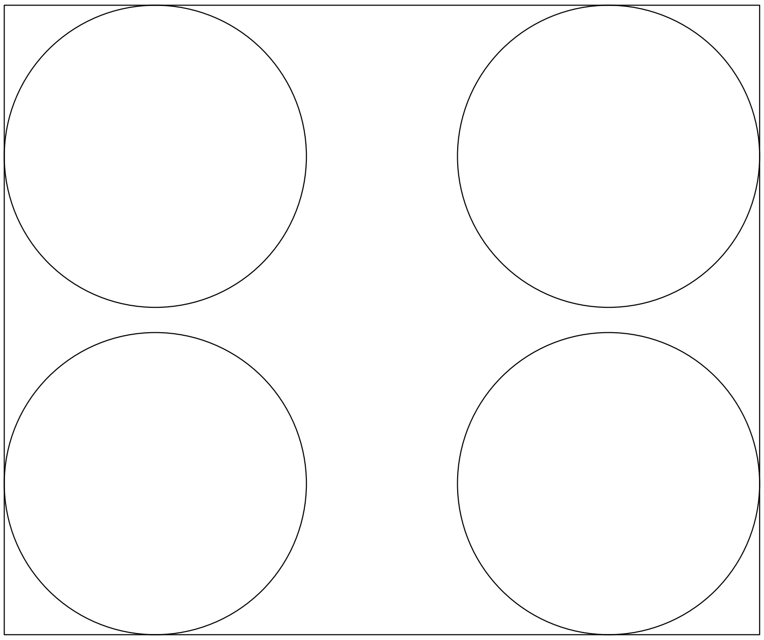

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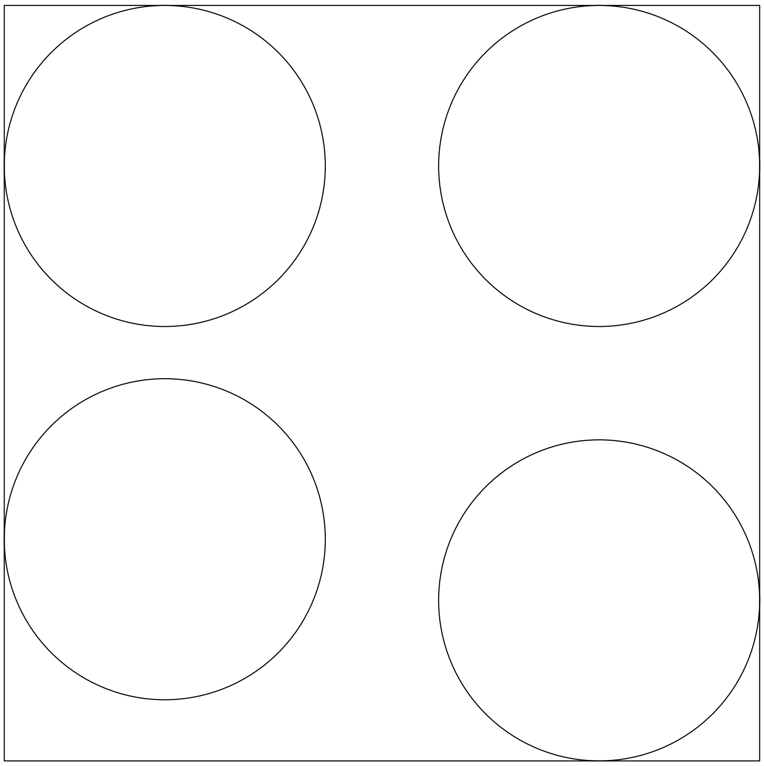

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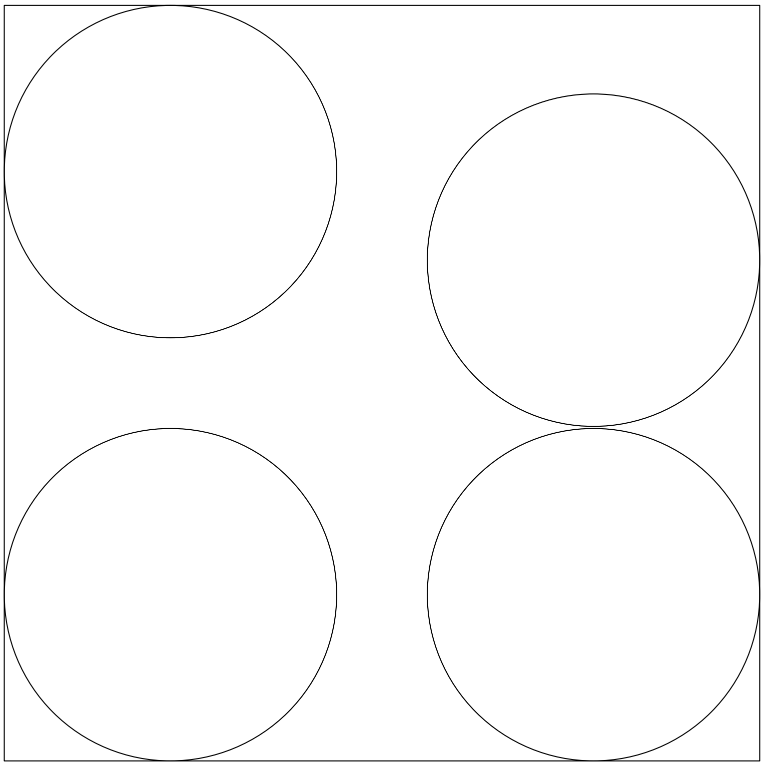

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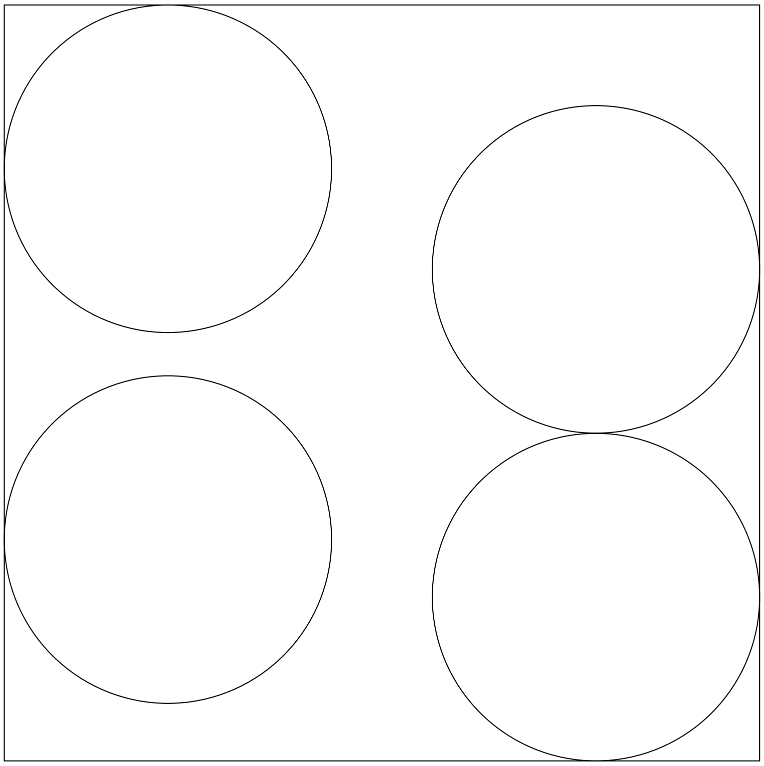

Figure 48: Problem 48.

References

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[2] E. G. Birgin, J. M. Martínez and D. P. Ronconi, Optimizing the Packing of Cylinders into a Rectangular Container: A Nonlinear Approach, *European Journal of Operational Research* 160, pp. 19–33, 2005.

[3] M. H. Correia, J. F. Oliveira, J. S. Ferreira, Cylinder Packing by Simulated Annealing, *Pesquisa Operacional* 20, pp. 269–284, 2000.

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