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TRIZ METHODOLOGY AND ITS USE IN SYSTEMATIC ENGINEERING DESIGN

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Abstract*. Technical innovation and creative problem solving are necessary for long-term business survival. Traditional methods for innovation and problem solving do not always suffice. In this paper, the TRIZ methodology for creative problem solving is presented and its possible use in systematic product planning and conceptual engineering design is discussed. TRIZ stands for Theory of Inventive Problem Solving, in Russian. It was created in the 1950s in ex-USSR and has been developed ever since, but it was unveiled to the West only some years ago. TRIZ is a powerful methodology for solving though technical problems. Initially, the basic concepts of TRIZ are introduced and its best known problem solving method - the inventive principles method - is presented. Then, a discussion on establishing a descriptive model of the product planning and conceptual engineering design process using concepts derived from TRIZ is made. For better understanding, illustrative examples are provided along the text.*

Keywords: *Engineering design, TRIZ, Design theory and methodology, Product planning, Conceptual design.*

1. INTRODUCTION

During the 1980's and 1990's, special attention was paid to the business function of manufacturing. Most companies have nowadays a quality system, mainly to assure final product or service conformance to specifications. Few companies have focused on improving their product development, to provide better products faster than the competitors. As competition becomes stronger, satisfying the customer is not enough anymore, and business strategies must be directed to innovation. Innovation can only be achieved by the concurrent actions of all business functions. This paper is related to technical innovation. More specifically, a powerful approach to technical innovation and creative problem solving known as TRIZ and its possible use within product planning and conceptual engineering design are presented.

Initially, TRIZ background and structure are presented. The underlying concepts of TRIZ - ideality, contradiction and resources - are discussed. Then, the most widely known problem solving method of TRIZ - known as inventive principles method - is presented. An example of this methods' application is described. Finally, a report of research underway is made. The research focuses on a descriptive model of the product planning and conceptual engineering design process using concepts derived from the systematic approach of Pahl & Beitz (1988), TRIZ and other methods.

2. BACKGROUND AND STRUCTURE OF TRIZ

Development of TRIZ started in the 1940s with works of Altshuller, in ex-USSR. Altshuller (1984a, 1984b, 1996) had the main objective of finding alternatives to traditional creative problem solving methods, that were based on trial and error. Altshuller approached technical creativity by its main evidences: patents. He tried to figure out the underlying process by which good solutions were found, no matter what type of technology was used. By doing so he found regularities, that constituted the foundation of a knowledge base and various methods for solving technical problems. Later, these methods were developed into what Altshuller named TRIZ – Theory of Inventive Problem Solving.

Modern TRIZ is a wealth of methods for finding and solving problems, a knowledge base, trends and laws. Main TRIZ researchers argue that the field is still in its infancy. TRIZ still has methodology status and has yet to be further developed to achieve theory, and possibly science status (Savransky, 1998b). The TRIZ methodology is relatively new to western countries, but interest in it is growing fast. For better understanding of the whole methodology, the complete structure of TRIZ is shown in Figure 1. The scope of this paper is limited to the items painted in grey. These items are the basic TRIZ concepts and one problem solving method. TRIZ problem solving methods are also known as contradiction removing methods.

3. MAIN CONCEPTS OF TRIZ

The underlying concepts of TRIZ methodology are ideality (and the trends and laws of technical systems evolution), contradiction and resources. These concepts are described below.

3.1. IDEALITY AND TECHNICAL SYSTEM EVOLUTION TRENDS AND LAWS

The s-curve is the pattern of investment for a product, process or technology's improvement versus obtained results (Foster, 1988). The curve is divided in four parts, or evolution phases (shown in Figure 1). These are:

a) new product, process or technology creation;
b) adoption by a small amount of users (product or process) or strong developments (technology);
c) market saturation (product or process) or small developments (technology);
d) substitution by a more advanced product, process or technology.

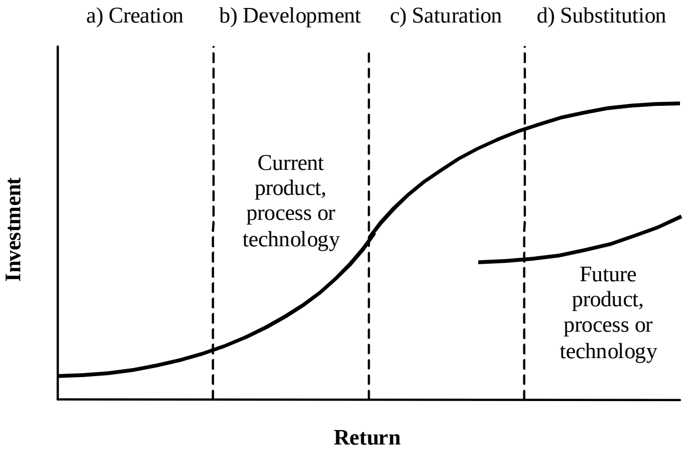

Figure 1 - The s-curve

Study of numerous products, processes and technologies has proven the pattern shown above But how does a product, process or technology itself evolves? Is the evolution unlimited? From his extensive patent research, Altshuller (1984a, 1984b) concluded that the evolution of products, processes and technologies - that he generically named technical systems - follows certain trends and laws. These are presented on Table 1. Technical systems evolve according to these trends and laws, and towards the ideal technical system (ITS). The ITS is a (non-) system that performs all necessary system functions. It is not and will never be a real system. Nevertheless, it is useful for establishing the direction for evolution of a real technical system.

The laws of creation are related to the S-curve phase a. According to the first law, there are some typical subsystems that every technical system should contain. These typical subsystems are engine, transmission, working system, control system and structure. The law of energy conduction capability means that, for a system's function to be achieved, energy should flow through its typical subsystems. The rythm synchronization law states that subsystems should have compatible working frequencies.

Development of technical systems (phases b and c of the s-curve) follows the laws of movement. The law of unlimited technical development means that a technical system can always be technically improved (even when such improvement is small and does result in sound effectiveness increase). According to the law of unequal subsystem development, subsystems are non-uniformly developed i.e., some subsystems underperform or overperform when compared to others in the same system. Overall system effectiveness can be achieved by developing underperforming subsystems. The law of transition to the supersystem states that, when increased effectiveness can not be achieved by the current technical system (or even before), it will be transformed into a subsystem of another, higher leveled technical system.

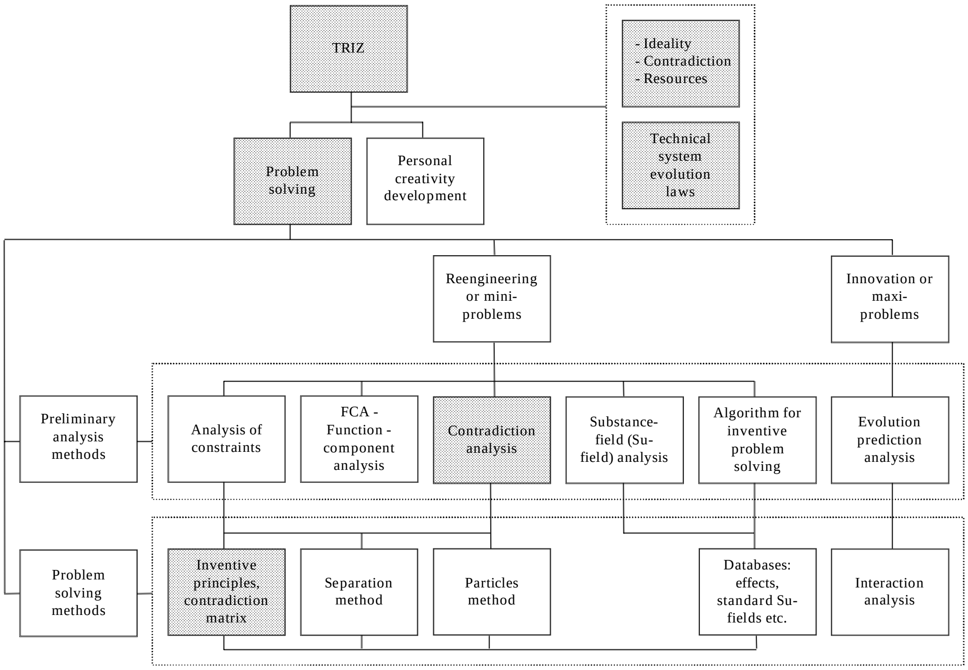

Figure 1 - Structure of TRIZ Methodology

The trends are related to the end of a technical systems' life (phases c and d of the s-curve). The trend of simplification states that sucessive generations of the same technical system evolve to complicated and then from complicated to simple, by integration. The trend of transition to subsystem means that increased effectiveness of a technical system is reached when it evolves from macrosystem to microsystem. Effectiveness is also increased by increasing system automation. According to the trend of increasing use of substance-fields, systems become more dynamic, more controlable, more durable and more effective when solid and stiff subsystems are replaced by interactions of substances and energy or information carriers.

Table 1 - Trends and laws of the evolution of technical systems

Group	Trends and laws
Laws of creation	Law of completeness
	Law of energy conduction capability
	Law of rythm synchronization
Laws of movement	Law of unlimited technical development
	Law of unequal subsystem development
	Law of transition to supersystem
Trends	Trend of simplification
	Trend of increasing number of functions
	Trend of transition to subsystem
	Trend of increasing automation
	Trend of increasing use of fields

3.2. CONTRADICTION

Contradictions can be defined as conflicting requirements on the same technical system. Considering an ordinary welding iron: the tip should be positioned far from the handle for not hurting operator's hands and should be close to the handle for better welding precision. Thus, the element that connects the handle to the tip should be long and should be short.

There are three possible approaches to solving a contradiction (Savransky, 1998): extremist, trade-off and creative. The extremist solutions to the welding iron problem are making the connecting element long or short. A long element would avoid hurting, and control would be difficult. A short element would make the iron easy to control, but operator's hands would be hurt. The trade-off solution would be making the connecting element not too short and not too long. A compromise is established between opposing requirements. The creative approach to the same problem means trying to comply to both opposing requirements. An example of creative solution would be giving the connecting element a horseshoe's form. By doing that, the operator's hand would be close to the tip for better control and would not be hurt, because the connecting element is long.

3.3. RESOURCES

Resources are elements of the system or its surroundings that are not being used but could be used to improve effectiveness. Types of resources include: internal, external, natural, system, functional, space, time, field (energy), substance, information etc. An example of using an available field resource was the invention of the turbocompressor to obtain overpressure of air in an internal combustion engine. The turbocompressor transforms a part of the energy of exhaust gases in intake air overpressure, making it unnecessary to use engine's mechanical power to compress intake air.

Using the laws of technical system evolution, solving system contradictions and using resources bring a technical system closer to the ITS.

4. PROBLEM SOLVING WITH TRIZ - THE INVENTIVE PRINCIPLES METHOD

From the point of view of mechanical systems design, problem solving can be considered TRIZ main part. Problem solving with TRIZ starts with a preliminary analysis. The objective of this analysis is to correctly formulate problems, define the ideal final result, verify the system according to the laws of evolution, find available resources, and find the contradictions to be solved. Only after the preliminary analysis should the problem-solving methods be used.

Contradiction analysis is a method for finding contradictions in a technical system. First, all system requirements should be listed. Then, pairs of requirements are comparatively analysed for contradictions. This process is very similar to - and could be even replaced by - the one of completing the roof in a house of quality.

After contradictions have been identified, a method for solving contradictions should be used. The method presented in this paper is the method of inventive principles.

The inventive principles method is one of the easiest and most popular TRIZ method. It is based on two main concepts: engineering parameters and inventive principles.

Engineering parameters are variables common to technical systems from different disciplines. The 39 engineering parameters are presented on Table 2.

Table 2 – Engineering parameters

1. Weight of moving object	11. Tension, pressure	21. Power	31. Harmful side effects
2. Weigh of binding object	12. Shape	22. Waste of energy	32. Manufacturability
3. Lenght of moving object	13. Stability	23. Waste of substance	33. Convenience of use
4. Lenght of binding object	14. Strenght	24. Loss of information	34. Repairability
5. Area of moving object	15. Durability of moving object	25. Waste of time	35. Adaptability
6. Area of binding object	16. Durability of binding object	26. Amount of substance	36. Complexity of object
7. Volume of moving object	17. Temperature	27. Reliability	37. Complexity of control
8. Volume of binding object	18. Brightness	28. Accuracy of measurement	38. Level of automation
9. Speed	19. Energy spent by moving object	29. Accuracy of manufacturing	39. Productivity
10. Force	20. Energy spent by binding object	30. Harmful factors acting on object	

The inventive principles are the result of generalization and grouping of solutions found in patents. These principles were repeatedly used in solving problems from different disciplines. The 40 inventive principles are shown in Table 3. For example, principle #35 – parameters and properties change could mean changing physical aggregate state, concentration, density, consistency, flexibility, temperature etc. Principle #10 could mean performing actions before needed, pre-arranging objects before they act etc. A detailed explanation of each inventive principle can be found in Altshuller (1996).

The contradiction matrix (presented in the Appendix) is a tool for selecting the inventive principle to be used to resolve a particular contradiction. In the matrix rows, engineering parameters that should be improved are listed. In the matrix' columns are the engineering parameters that can be degraded as a result of improving the parameter in the row. The numbers at the intersecting cells correspond to the inventive principles that most probably point to the contradiction resolution. The inventive principles can also be used without the matrix. In this case, the problem solver looks at the list and tries to derive from it useful ideas to solve his/her problem.

The problem described below is simple and could be solved with other methods, but it will be used to illustrate problem solving with the inventive principles method.

The bracket shown in Figure 2 is used in the transmission of a fun kart under development at CEFET-PR. This part is supported by the rear axle, which passes through the inferior hole. The superior hole supports an intermediary axle. The bracket must rotate around point A (rear axle center line). At present, the distance between superior and inferior holes (distance C) is unchangeable. It is necessary to make distance C changeable. In fact, it must be easy to adjust distance C and, once it is adjusted, to keep the adjustment.

Table 3 – Inventive principles

1. Segmentation	11. Beforehand cushioning	21. Skipping	31. Porous materials and membranes
2. Taking out	12. Equipotentiality	22. Converting harm into benefit	32. Color changes
3. Local quality	13. Reverse	23. Feedback	33. Homogeneity
4. Asymmetry	14. Spheroidality	24. Intermediary principle	34. Discarding and recovering
5. Merging	15. Dynamism	25. Self-service	35. Parameters and properties change
6. Universality	16. Parcial or excessive action	26. Copying	36. Phase transitions
7. Nested doll	17. Another dimension	27. Cheap short-living objects	37. Thermal expansion
8. Anti-weight	18. Mechanical vibration	28. Substitution of mechanics	38. Strong oxidants
9. Preliminary anti-action	19. Periodic action	29. Pneumatics or hydraulics	39. Inert atmosphere
10. Preliminary action	20. Continuity of useful action	30. Flexible shells and thin films	40. Composite materials

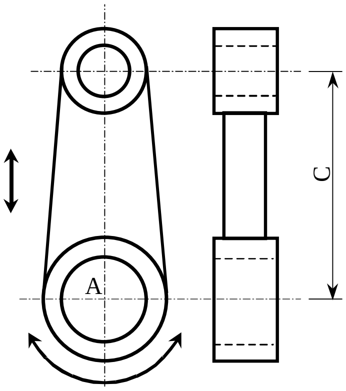

Figure 2 - Fun kart transmission bracket

The ideal transmission bracket is no bracket at all. The closest to ideal bracket is one that adjusts itself to the required distance C and keeps itself adjusted.

Available resources include available clearances, surrounding components that could be modified to carry out bracket functions, unused material properties, material that does not carry load with present geometry, available energy (vibration, rotation), gravity, movement of surrounding components etc.

The contradiction is: the bracket has to be dynamic for adjustment and has to be static for keeping the clearance. This contradiction has to be translated into engineering parameters. The chosen parameters are #35 (adaptability) and #12 (shape). The intersection of line #35 and column #12 of the contradiction matrix results in principles #15 (dynamism), #37 (thermal expansion), #1 (segmentation) and #8 (anti-weight). These principles should be used for deriving conceptual solutions to the problem. Several concepts were generated and two of the most promising are shown in Figure 3.

In the solution at left, the bracket is separated in two parts (1 and 2). These parts are connected by a grooved pin (5) that is kept in position by a nut (3), a washer (4) and an elastic ring (6). Adjustment is done by removing the nut and washer, partially removing the grooved pin, repositioning and fastening the parts.

The solution at right involves a double-threaded screw (3), two nuts (2) and two connecting elements (1 and 4). Both solutions are based on inventive principles #15 and #1.

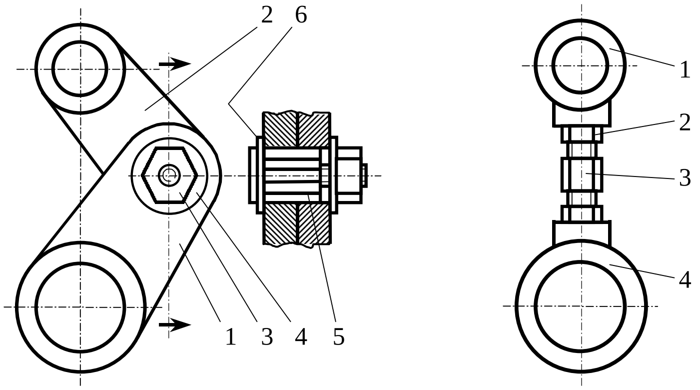

Figure 2 - Two solutions to the fun kart transmission bracket problem

5. USE OF TRIZ IN MECHANICAL SYSTEMS DESIGN

The systematic approach to engineering design proposed by Pahl & Beitz (1988) is a well proven methodology, valid for component design as well as complex systems design. TRIZ includes some very useful elements that are not included in the traditional systematic approach to mechanical systems design. Altough TRIZ is based on knowledge from all technical areas, its scope is narrow, directed to specific problems. How could TRIZ be effectively used in systematic design?

According to León-Rovira & Aguayo (1998), TRIZ concepts of ideality, contradiction and resources should be used along the whole design process. TRIZ problem solving methods can be used for removing contradictions every time these are found.

Terninko (1998) and Domb (1998) suggest combining TRIZ, QFD and Robust Design. QFD should be used to identify conflicts between requirements (house of quality roof), that could be resolved with TRIZ. Robust design should be used to find optimum levels of technical parameters.

Savransky (1998b) suggests using TRIZ methods in the upfront of the development process, for obtaining innovative concepts. Traditional engineering methods should then be used for further concept development. According to Savransky (1998b), the same procedure could be used to redesign products.

Malmquist et al. (1996) suggest unifying TRIZ and the systematic approach. The systematic approach should be used as a framework with TRIZ elements included in some points. Linde & Hill (1993) have proposed WOIS - *Widerspruchsorientierte Innovationsstrategie* or Contradiction-Oriented Innovation Strategy. This is a methodology for complex product development, based on German systematic design methodologies and

TRIZ. In their book, Linde & Hill present many case studies, proving that their approach works properly.

The authors are presently working on a descriptive model of systematic product planning and conceptual design based on the systematic approach by Pahl & Beitz (1988), TRIZ, and other creative problem solving methods. There are two central ideas to be implemented in this model:

- to enhance reuse of design knowledge available in catalogs of conceptual solutions, patent funds, and other sources;
- when development of solutions is needed, to prompt the engineering design team to use the most appropriate method for each type of problem. Use of effective but difficult problem solving methods like those of TRIZ is proposed only after trying to solve problems with simpler methods like brainstorming (Osborn, 1953).

6. CONCLUSIONS

In this paper, the TRIZ approach to technical innovation and creative problem solving was presented. Background, structure, main underlying concepts, and a problem solving method – the inventive principles method – were described. Finally, possible use of TRIZ within product planning and conceptual engineering design was analysed.

TRIZ is a powerful methodology for creative problem solving and innovation. It is however complex, knowledge intensive, and focused on specific problems. Its integration with systematic engineering design would result in a stronger methodology. The integration should occur according to following guidelines:

- systematic engineeering design should be used as a framework, because it has a broader scope;
- reuse of available design knowledge should be enhanced and problem solving should be used only when necessary;
- the methodology should be progressive, i.e. use of complex problem solving methods like those of TRIZ should be avoided when not necessary.

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APPENDIX - CONTRADICTION MATRIX

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
1			15. 8. 29. 34		29. 17. 38. 34		29. 2. 40. 28		2. 8. 15. 38	8. 10. 18. 37	10. 36. 37. 40	10. 14. 35. 40	1. 35. 19. 39	28. 27. 18. 40	5. 34. 31. 35		6. 29. 4. 38	19. 1. 32	35. 12. 34. 31		12. 36. 18. 31	6. 2. 34. 19	5. 35. 3. 31	10. 24. 35	10. 35. 20. 28	3. 26. 18. 31	3. 11. 1. 27	28. 27. 35. 26	28. 35. 26. 18	22. 21. 18. 27	22. 35. 31. 39	27. 28. 1. 36	35. 3. 2. 24	2. 27. 28. 11	29. 5. 15. 8	26. 30. 36. 34	28. 29. 26. 32	26. 35. 18. 19	35. 3. 24. 37
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13	21. 35. 2. 39	26. 39. 1. 40	13. 15. 1. 28	37	2. 11. 13	39	28. 10. 19. 39	34. 28. 35. 40	33. 15. 28. 18	10. 35. 21. 16	2. 35. 40	22. 1. 18. 4		17. 9. 15	13. 27. 10. 35	39. 3. 35. 23	35. 1. 32	32. 3. 27. 15	13. 19	27. 4. 29. 18	32. 35. 27. 31	14. 2. 39. 6	2. 14. 30. 40		35. 27	15. 32. 35		13	18	35. 23. 18. 30	35. 40. 27. 39	35. 19	32. 35. 30	2. 35. 10. 16	35. 30. 34. 2	2. 35. 22. 26	35. 22. 39. 23	1. 8. 35	23. 35. 40. 3
14	1. 8. 40. 15	40. 26. 27. 1	1. 15. 8. 35	15. 14. 28. 26	3. 34. 40. 29	9. 40. 28	10. 15. 14. 7	9. 14. 17. 15	8. 13. 26. 14	10. 18. 3. 14	10. 3. 18. 40	10. 30. 35. 40	13. 17. 35		27. 3. 26		30. 10. 40	35. 19	19. 35. 10	35	10. 26. 35. 28	35	35. 28. 31. 40		29. 3. 28. 10	29. 10. 27	11. 3	3. 27. 16	3. 27	18. 35. 37. 1	15. 35. 22. 2	11. 3. 10. 32	32. 40. 28. 2	27. 11. 3	15. 3. 32	2. 13. 28	27. 3. 15. 40	15	29. 35. 10. 14
15	19. 5. 34. 31		2. 19. 9		3. 17. 19		10. 2. 19. 30		3. 35. 5	19. 2. 16	19. 3. 27	14. 26. 28. 25	13. 3. 35	27. 3. 10			19. 35. 39	2. 19. 4. 35	28. 6. 35. 18		19. 10. 35. 38		28. 27. 3. 18	10	20. 10. 28. 18	3. 35. 10. 40	11. 2. 13	3	3. 27. 16. 40	22. 15. 33. 28	21. 39. 16. 22	27. 1. 4	12. 27	29. 10. 27	1. 35. 13	10. 4. 29. 15	19. 29. 39. 35	6. 10	35. 17. 14. 19
16		6. 27. 19. 16		1. 40. 35				35. 34. 38					39. 3. 35. 23				19. 18. 36. 40				16		27. 16. 18. 38	10	28. 20. 10. 16	3. 35. 31	34. 27. 6. 40	10. 26. 24		17. 1. 40. 33	22	35. 10	1	1	2		25. 34. 6. 35	1	20. 10. 16. 38
17	36. 22. 6. 38	22. 35. 32	15. 19. 9	15. 19. 9	3. 35. 39. 18	35. 38	34. 39. 40. 18	35. 6. 4	2. 28. 36. 30	35. 10. 3. 21	35. 39. 19. 2	14. 22. 19. 32	1. 35. 32	10. 30. 22. 40	19. 13. 39	19. 18. 36. 40		32. 30. 21. 16	19. 15. 3. 17		2. 14. 17. 25	21. 17. 35. 38	21. 36. 29. 31		35. 28. 21. 18	3. 17. 30. 39	19. 35. 3. 10	32. 19. 24	24	22. 33. 35. 2	22. 35. 2. 24	26. 27	26. 27	4. 10. 16	2. 18. 27	2. 17. 16	3. 27. 35. 31	23. 2. 19. 16	15. 28. 35
18	19. 1. 32	2. 35. 32	19. 32. 16		19. 32. 26		2. 13. 10		10. 13. 19	26. 19. 6		32. 30	32. 3. 27	35. 19	2. 19. 6		32. 35. 19		32. 1. 19	32. 35. 1. 15	32	19. 16. 1. 6	13. 1	1. 6	19. 1. 26. 17	1. 19		11. 15. 32	3. 32	15. 19	35. 19. 32. 39	19. 35. 28. 26	28. 26. 19	15. 17. 13. 16	15. 1. 19	6. 32. 13	32. 15	2. 26. 10	2. 25. 16
19	12. 18. 28. 31		12. 28		15. 19. 25		35. 13. 18		8. 15. 35	16. 26. 21. 2	23. 14. 25	12. 2. 29	19. 13. 17. 24	5. 19. 9. 35	28. 35. 6. 18		19. 24. 3. 14	2. 15. 19			6. 19. 37. 18	12. 22. 15. 24	35. 24. 18. 5		35. 38. 19. 18	34. 23. 16. 18	19. 21. 11. 27	3. 1. 32		1. 35. 6. 27	2. 35. 6	28. 26. 30	19. 35	1. 15. 17. 28	15. 17. 13. 16	2. 29. 27. 28	35. 38	32. 2	12. 28. 35
20		19. 9. 6. 27								36. 37			27. 4. 29. 18	35				19. 2. 35. 32					28. 27. 18. 31			3. 35. 31	10. 36. 23			10. 2. 22. 37	19. 22. 18	1. 4					19. 35. 16. 25		1. 6
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22	15. 6. 19. 28	19. 6. 18. 9	7. 2. 6. 13	6. 38. 7	15. 26. 17. 30	17. 7. 30. 18	7. 18. 23	7	16. 35. 38	36. 38			14. 2. 39. 6	26			19. 38. 7	1. 13. 32. 15			3. 38		35. 27. 2. 37	19. 10	10. 18. 32. 7	7. 18. 25	11. 10. 35	32		21. 22. 35. 2	21. 35. 2. 22		35. 32. 1	2. 19		7. 23	35. 3. 15. 23	2	28. 10. 29. 35
23	35. 6. 23. 40	35. 6. 22. 32	14. 29. 10. 39	10. 28. 24	35. 2. 10. 31	10. 18. 39. 31	1. 29. 30. 36	3. 39. 18. 31	10. 13. 28. 38	14. 15. 18. 40	3. 36. 37. 10	29. 35. 3. 5	2. 14. 30. 40	35. 28. 31. 40	28. 27. 3. 18	27. 16. 18. 38	21. 36. 39. 31	1. 6. 13	35. 18. 24. 5	28. 27. 12. 31	28. 27. 18. 38	35. 27. 2. 31			15. 18. 35. 10	6. 3. 10. 24	10. 29. 39. 35	16. 34. 31. 28	35. 10. 24. 31	33. 22. 30. 10	10. 1. 34. 29	15. 34. 33	32. 28. 2. 24	2. 35. 34. 27	15. 10. 2	35. 10. 28. 24	35. 18. 10. 13	35. 10. 18	28. 35. 10. 23
24	10. 24. 35	10. 35. 5	1. 26	26	30. 26	30. 16		2. 22	26. 32						10	10		19			10. 19	19. 10			24. 26. 28. 32	24. 28. 35	10. 28. 23			22. 10. 1	10. 21. 22	32	27. 22				35. 33	35	13. 23. 15
25	10. 20. 37. 35	10. 20. 26. 5	15. 2. 29	30. 24. 14. 5	26. 4. 5. 16	10. 35. 17. 4	2. 5. 34. 10	35. 16. 32. 18		10. 37. 36. 5	37. 36. 4	4. 10. 34. 17	35. 3. 22. 5	29. 3. 28. 18	20. 10. 28. 18	28. 20. 10. 16	35. 29. 21. 18	1. 19. 21. 17	35. 38. 19. 18	1	35. 20. 10. 6	10. 5. 18. 32	35. 18. 10. 39	24. 26. 28. 32		35. 38. 18. 16	10. 30. 4	24. 34. 28. 32	24. 26. 28. 18	35. 18. 34	35. 22. 18. 39	35. 28. 34. 4	4. 28. 10. 34	32. 1. 10	35. 28	6. 29	18. 28. 32. 10	24. 28. 35. 30	
26	35. 6. 18. 31	27. 26. 18. 35	29. 14. 35. 18		15. 14. 29	2. 18. 40. 4	15. 20. 29		35. 29. 34. 28	35. 14. 3	10. 36. 14. 3	35. 14	15. 2. 17. 40	14. 35. 34. 10	3. 35. 10. 40	3. 35. 31	3. 17. 39		34. 29. 16. 18	3. 35. 31	35	7. 18. 25	6. 3. 10. 24	24. 28. 35	35. 38. 18316		18. 3. 28. 40	3. 2. 28	33. 30	35. 33. 29. 31	3. 35. 40. 39	29. 1. 35. 27	35. 29. 10. 25	2. 32. 10. 25	15. 3. 29	3. 13. 27. 10	3. 27. 29. 18	8. 35	13. 29. 3. 27
27	3. 8. 10. 40	3. 10. 8. 28	15. 9. 14. 4	15. 29. 28. 11	17. 10. 14. 16	32. 35. 40. 4	3. 10. 14. 24	2. 35. 24	21. 35. 11. 28	8. 28. 10. 3	10. 24. 35. 19	35. 1. 16. 11		11. 28	2. 35. 3. 25	34. 27. 6. 40	3. 35. 10	11. 32. 13	21. 11. 27. 19	36. 23	21. 11. 26. 31	10. 11. 35	10. 35. 29. 39	10. 28	10. 30. 4	21. 28. 40. 3		32. 3. 11. 23	11. 32. 1	27. 35. 2. 40	35. 2. 40. 26		27. 17. 40	1. 11	13. 35. 8. 24	13. 35. 1	27. 40. 28	11. 13. 27	1. 35. 29. 38
28	32. 35. 26. 28	28. 35. 25. 26	28. 26. 5. 16	32. 28. 3. 16	26. 28. 32. 3	26. 28. 32. 3	32. 13. 6		28. 13. 32. 24	32. 2	6. 28. 32	6. 28. 32	32. 35. 13	28. 6. 32	28. 6. 32	10. 26. 24	6. 19. 28. 24	6. 1. 32	3. 6. 32		3. 6. 32	26. 32. 27	10. 16. 31. 28		24. 34. 28. 32	2. 6. 32	5. 11. 1. 23			28. 24. 22. 26	3. 33. 39. 10	6. 35. 25. 18	1. 13. 17. 34	1. 32. 13. 11	13. 35. 2	27. 35. 10. 34	26. 24. 32. 28	28. 2. 10. 34	10. 34. 28. 32
29	28. 32. 13. 18	28. 35. 27. 9	10. 28. 29. 37	2. 32. 10	28. 33. 29. 32	2. 29. 18. 36	32. 28. 2	25. 10. 35	10. 28. 32	28. 19. 34. 36	3. 35	32. 30. 40	30. 18	3. 27	3. 27. 40		19. 26	3. 32	32. 2		32. 2	13. 32. 2	35. 31. 10. 24		32. 26. 28. 18	32. 30	11. 32. 1			26. 28. 10. 36	4. 17. 34. 26		1. 32. 35. 23	25. 10		26. 2. 18		26. 28. 18. 23	10. 18. 32. 39
30	22. 21. 27. 39	2. 22. 13. 24	17. 1. 39. 4	1. 18	22. 1. 33. 28	27. 2. 39. 35	22. 23. 37. 35	34. 39. 19. 27	21. 22. 35. 28	13. 35. 39. 18	22. 2. 37	22. 1. 3. 35	35. 24. 30. 18	18. 35. 37. 1	22. 15. 33. 28	17. 1. 40. 33	22. 33. 35. 2	1. 19. 32. 13	1. 24. 6. 27	10. 2. 22. 37	19. 22. 31. 2	21. 22. 35. 2	33. 22. 19. 40	22. 10. 2	35. 18. 34	35. 33. 29. 31	27. 24. 2. 40	28. 33. 23. 26	26. 28. 10. 18			24. 35. 2	2. 25. 28. 39	35. 10. 2	35. 11. 22. 31	22. 19. 29. 40	22. 19. 29. 40	33. 3. 34	22. 35. 13. 24
31	19. 22. 15. 39	35. 22. 1. 39	17. 15. 16. 22		17. 2. 18. 39	22. 1. 40	17. 2. 40	30. 18. 35. 4	35. 28. 3. 23	35. 28. 1. 40	2. 33. 27. 18	35. 1	35. 40. 27. 39	15. 35. 22. 2	15. 22. 33. 31	21. 39. 16. 22	22. 35. 2. 24	19. 24. 39. 32	2. 35. 6	19. 22. 18	2. 35. 18	21. 35. 22. 2	10. 1. 34	10. 21. 29	1. 22	3. 24. 39. 1	24. 2. 40. 39	3. 33. 26	4. 17. 34. 26							19. 1. 31	2. 21. 27. 1	2	22. 35. 18. 39
32	28. 29. 15. 16	1. 27. 36. 13	1. 29. 13. 17	15. 17. 27	13. 1. 26. 12	16. 4	13. 29. 1. 40	35	35. 13. 8. 1	35. 12	35. 19. 1. 37	1. 28. 13. 27	11. 13. 1	1. 3. 10. 32	27. 1. 4	35. 16	27. 26. 18	28. 24. 27. 1	28. 26. 27. 1	1. 4	27. 1. 12. 24	19. 35	15. 34. 33	32. 24. 18. 16	35. 28. 34. 4	35. 23. 1. 24		1. 35. 12. 18		24. 2			2. 5. 13. 16	35. 1. 11. 9	2. 13. 15	27. 26. 1	6. 28. 11. 1	8. 28. 1	35. 1. 10. 28
33	25. 2. 13. 15	6. 13. 1. 25	1. 17. 13. 12		1. 17. 13. 16	18. 16. 15. 39	1. 16. 35. 15	4. 18. 31. 39	18. 13. 34	28. 13. 35	2. 32. 12	15. 34. 29. 28	32. 35. 30	32. 40. 3. 28	29. 3. 8. 25	1. 16. 25	26327. 13	13. 17. 1. 24	1. 13. 24		35. 34. 2. 10	2. 19. 13	28. 32. 2. 24	4. 10. 27. 22	4. 28. 10. 34	12. 35	17. 27. 8. 40	25. 13. 2. 34	1. 32. 35. 23	2. 25. 28. 39		2. 5. 12		12. 26. 1. 32	15. 34. 1. 16	32. 25. 12. 17		1. 34. 12. 3	15. 1. 28
34	2. 27. 35. 11	2. 27. 35. 11	1. 28. 10. 25	3. 18. 31	15. 32. 13	16. 25	25. 2. 35. 11	1	34. 9	1. 11. 10	13	1. 13. 2. 4	2. 35	1. 11. 2. 9	11. 29. 28. 27	1	4. 10	15. 1. 13	15. 1. 28. 16		15. 10. 32. 2	15. 1. 32. 19	2. 35. 34. 27		32. 1. 10. 25	2. 28. 10. 25	11. 10. 1. 16	10. 2. 13	25. 10	35. 102. 16		1. 35. 11. 10	1. 12. 26. 15		7. 1. 4. 16	35. 1. 13. 11		34. 35. 7. 13	1. 32. 10
35	1. 6. 15. 8	19. 15. 29. 16	35. 1. 29. 2	1. 35. 16	35. 30. 29. 7	15. 16	15. 35. 29		35. 10. 14	15. 17. 20	35. 16	15. 37. 1. 8	35. 30. 14	35. 3. 32. 6	13. 1. 35	2. 16	27. 2. 3. 35	6. 22. 26. 1	19. 35. 29. 13		19. 1. 29	18. 15. 1	15. 10. 2. 13		35. 28	3. 35. 15	35. 13. 8. 24	35. 5. 1. 10		35. 11. 32. 31		1. 13. 31	15. 34. 1. 16	1. 16. 7. 4		15. 29. 37. 28	1	27. 34. 35	35. 28. 6. 37
36	26. 30. 34. 36	2. 26. 35. 39	1. 19. 26. 24	26	14. 1. 13. 16	6. 36	34. 26. 6	1. 16	34. 10. 28	26. 16	19. 1. 35	29. 13. 28. 15	2. 22. 17. 19	2. 13. 28	10. 4. 28. 15		2. 17. 13	24. 17. 13	27. 2. 29. 28		20. 19. 30. 34	10. 35. 13. 2	35. 10. 28. 29		6. 29	13. 3. 27. 10	13. 35. 1	2. 26. 10. 34	26. 24. 32	22. 19. 29. 40	19. 1	27. 26. 1. 13	27. 9. 26. 24	1. 13	29. 15. 28. 37		15. 10. 37. 28	15. 1. 24	12. 17. 28
37	27. 26. 28. 13	6. 13. 28. 1	16. 17. 26. 24	26	2. 13. 18. 17	2. 39. 30. 16	29. 1. 4. 16	2. 18. 26. 31	3. 4. 16. 35	36. 28. 40. 19	35. 36. 37. 32	27. 13. 1. 39	11. 22. 39. 30	27. 3. 15. 28	19. 29. 25. 39	25. 34. 6. 35	3. 27. 35. 16	2. 24. 26	35. 38	19. 35. 16	19. 1. 16. 10	35. 3. 15. 19	1. 18. 10. 24	35. 33. 27. 22	18. 28. 32. 9	3. 27. 29. 18	27. 40. 28. 8	26. 24. 32. 28		22. 19. 29. 28	2. 21	5. 28. 11. 29	2. 5	12. 26	1. 15	15. 10. 37. 28		34. 21	35. 18
38	28. 26. 18. 35	28. 26. 35. 10	14. 13. 28. 17	23	17. 14. 13		35. 13. 16		28. 10	2. 35	13. 35	15. 32. 1. 13	18. 1	25. 13	6. 9		26. 2. 19	8. 32. 19	2. 32. 13		28. 2. 27	23. 28	35. 10. 18. 5	35. 33	24. 28. 35. 30	35. 13	11. 27. 32	28. 26. 10. 34	28. 26. 18. 23	2. 33	2	1. 26. 13	1. 12. 34. 3	1. 35. 13	27. 4. 1. 35	15. 24. 10	34. 27. 25		5. 12. 35. 26
39	35. 26. 24. 37	28. 27. 15. 3	18. 4. 28. 38	30. 7. 14. 26	10. 26. 34. 31	10. 35. 17. 7	2. 6. 34. 10	35. 37. 10. 2		28. 15. 10. 36	10. 37. 14	14. 10. 34. 40	35. 3. 22. 39	29. 28. 10. 18	35. 10. 2. 18	20. 10. 16. 38	35. 21. 28. 10	26. 17. 19. 1	35. 10. 38. 19	1	35. 20. 10	28. 10. 29. 35	28. 10. 35. 23	13. 15. 23		35. 38	1. 35. 10. 38	1. 10. 34. 28	32. 1. 18. 10	22. 35. 13. 24	35. 22. 18. 39	35. 28. 2. 24	1. 28. 7. 19	1. 32. 10. 25	1. 35. 28. 37	12. 17. 28. 24	35. 18. 27. 2	5. 12. 35. 26	