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Forward supply Chain network design problem: Heuristic approaches

İleri tedarik zinciri ağ tasarımı problemi: Sezgisel yaklaşımlar

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Abstract

Determining positions and counting of actors, amount of product flow between and decreasing transportation costs are handled as a network design problem in supply chain management. Supply chain network design (SCND) problem belongs to the class of NP-hard problems. It has therefore appealed to a number of researchers' close attention. However, existing literature lacks of common benchmark instances for forward SCND problems so as to make a fair comparison between developed and applied heuristic approaches. To this end, 450 new benchmark instances ranging from small to large size for forward SCND problems with two, three and four-echelon are generated and a mathematical model for each of the problems is formulated. Due to the complexity issues, we develop two heuristic solution approaches, genetic algorithm (GA) and hybrid heuristic algorithm (HHA), and we apply them to the large pool of benchmark instances. Comparative experiments show that both the GA and HHA can yield feasible solutions in much less computational time and, in particular, outperforms CPLEX regarding the solution quality as the number of echelon grows.

Keywords: Supply chain network design, mixed integer programming; genetic algorithm; hybrid heuristic algorithm.

1 Introduction

A classical supply chain refers to a broad set of activities associated with the transformation and flow of goods and services, including the flow of information, from the sources of materials to end-users [1]-[3]. Nowadays, a supply chain network can take three main forms namely; forward, reverse and closed-loop supply chain [4]. Whereas forward supply chain (FSC) can be defined as flow of goods from source to end-users in a supply chain, reverse supply chain (RSC) can be defined as a process that includes all logistics activities and starts from the point of end-users to transform the used products to products which are reusable in the market [5],[6]. Finally, if all forward and reverse supply chain activities are combined is known to be one of a closed-loop, and research on such chains have given rise to the field of closed-loop supply chain (CLSC) [7] (see Figure 1).

The operation/distribution plans of a supply chain involving forward, reverse or closed-loop need to be optimized. Determining positions and counting of actors, amount of

Öz

Tedarik zinciri içindeki tesislerin yerlerinin belirlenmesi, aralarındaki ürün akışlarının maliyeti minimize edecek şekilde optimize edilmesi tedarik zinciri ağ tasarımı (TZAT) problemi olarak karşımıza çıkmaktadır. TZAT problemleri NP-zor sınıfına girmektedir. Dolayısıyla çoğu araştırmacı tarafından üzerinde çalışılan bir konudur. Ancak literatürde araştırmacıların adil karşılaştırmalar yapabileceği test problemler mevcut değildir. Bu sebeple, küçük boyuttan büyük boyuta kadar iki, üç ve dört aşamalı olmak üzere 450 adet TZAT test problemi geliştirilmiş, matematiksel olarak da modellenmiştir. Problemin çözüm karmaşıklığından dolayı biri genetik algoritma diğeri de melez sezgisel bir yaklaşım olmak üzere iki farklı çözüm yöntemi önerilmiştir. Önerilen yaklaşımlar geliştirilen test problemlere uygulanmış ve karşılaştırmalar yapılmıştır. Elde edilen sonuçlara göre önerilen sezgisel yaklaşımlar küçük boyutlu problemler için CPLEX ile elde edilen optimal sonuçları yakalamış, büyük boyutlu problemler için ise çok daha kısa sürede kabul edilebilir sonuçlar elde etmiştir.

Anahtar kelimeler: Tedarik zinciri ağ tasarımı, karma tamsayılı programlama, genetik algoritma, melez sezgisel algoritma.

product flow between and decreasing transportation costs are handled as a network design problem in supply chain management.

The design task may include,

- location of facilities (plants, retailers, distribution centers, disassembly centers, collection centers etc.) to be opened,
- design of the network configuration,
- meeting customer's demand so as to minimize the total cost consist of fixed operating cost and transportation cost [8]-[11].

Most of the SCND problems can be reduced to the capacitated facility location problem, which is proven to be NP-hard; therefore, SCND problems belong to the class of NP-hard problems as well [8]. To cope with the complexity of the SCND problems and to obtain acceptable solutions in reasonable amount of time, many heuristic and meta-heuristics algorithms are developed and applied in the last decade [12]-[15].



Figure 1: Typical FSC (1), RSC (2) and CLSC (3) networks.

However, literature lacks of benchmark problems for SCND problems to make a fair comparison between developed and applied approaches. Although there are well-known benchmark problems in traveling salesman problems [16], vehicle routing problem with time windows [17] and assembly line balancing problems [18], to the best of our knowledge, no benchmark or common problems are introduced in SCND problem area. A well-established set of benchmark instances provides a good base for future studies on the field of SCND.

The scientific contributions of this study are given as follows. We first model SCND problems as mixed integer linear programming formulations, and we develop two different solution approaches based on the genetic algorithm (GA) and hybrid heuristic algorithm (HHA). We then generate 450 test instances with varying number echelons through a broad

problem set, and we comparatively analyze the effectiveness of the two GA and HHA.

The rest of the article is presented as follows. In the next part, we provide an overview and a summary of the existing literature on forward SCND problems. Basic formulation of forward SCND problem and generation of benchmark instances are given in Section 3. Sections 4 and 5 explain the adopted solution methodology based on GA and HHA, respectively. Section 6 discusses the comparative results on the set of instances. Last part of study (Section 7), conclusions and future directions are given.

2 Literature review

One of the most popular problems is designing and optimizing forward SCND problem, received substantial attention from academicians, researchers and operators in supply chain management research field. For that reason, many heuristic algorithm and mathematical models have been presented. The literature on the forward SCND problem is fruitful and the readers are referred to the comprehensive surveys given in Table 1 for a recent coverage of the state-of-the-art on models and solution algorithms. Table 1 also lists the possible future research directions provided by the authors.

In addition to the surveys, current test problems generated by the researchers for forward SCND problems to test their proposed solution approaches are given in Table 2. Information in Table 2 is classified based on the number of facilities, number of the test problems, proposed approach and comparisons (if exists). The minimum and the maximum number of facilities are given in the cells with dash. With regard to the reviewed studies, the vast majority presents a three-echelon structure, and mainly combines the presence of suppliers, plants, distribution centers/retailers and customers.

While early studies consider single echelon structure [19]-[21], two echelon supply chains have recently drawn attention of

some researchers [22],[23]. In modeling approach, a great deal of the studies reviewed for the linear programming-based modeling approach, especially mixed integer linear programming models [11],[24],[25]. On the contrary, nonlinear programming is only used in two papers [26]-[28].

The inclusion of uncertainty in the various models is achieved by stochastic programming [23],[26]. Likewise, heuristic and meta-heuristics are used as complementary techniques to solve mathematical programming models in a reasonable time [8],[9],[20],[22],[29]-[31]. In the objective frame, minimization of total costs (especially shipping and fixed costs) is the main objective of the studies reviewed while maximization of sales/revenues [11],[32] and customer service [27] are considered to a lesser extent.

Regarding costs, the minimization of shipping cost [8], fixed cost [22], inventory cost [33], backorder cost [34], production cost [35] are considered for forward SCND problems. The maximization of capacity utilization is also taken into account by Altiparmak et al. [27].

Table 1	Charactoristics	of oarlior	roviow	studios or	forward SCND n	roblome
Table 1	character issues	of earlier	review	studies of	i ioi waru Sund p	Toblems.

Reference	Date range	No. of reviewed papers	Suggestions
Meixell and Gargeya [36]	1982- 2005	18	 Need to address the composite supply chain design problem by extending models to include both external supplier locations and internal manufacturing. The performance measures used in global supply chain models need to be broadened in definition to address alternative objectives. More industry settings need to be explored in the context of global supply design.
Melo et al. [37]	1992- 2008	60	• The integration of strategic and tactical / operational decisions in supply chain planning.
Mula et al. [38]	1984- 2009	44	 Integration and/or the hierarchical structure of the tactical and operative planning levels in the supply chain context. Consideration of the different forms of transport (routes, full truck load, grouping, milk round) products among the various nodes of the supply chain. Comparisons made among the centralized and decentralized planning stages of the supply chain. Applying the planning models to real case studies.
Badole et al. [12]	2001- 2010	302	 Some of the missing and most critical performance measures should include information productivity, cost of data processing and information, risk of not using an information technology, and the implications of outsourcing. Research on perishable products is comparatively scarce. A need for the design and implementation of a humanitarian and disaster supply chain.
Fahimnia et al. [13]	1991- 2011	135	 Needing a range of variables and constraints to be incorporated in supply chain models. Requiring quantifying and formulating multiple supply chain performance indicators including both traditional and contemporary objective functions (e.g. cost, service level, social impact, environmental impact, and safety measures).
Lambiase et al. [14]	2000- 2012	50	 Consideration the development of a supply chain model using a profit maximization objective function, including as many strategic decisions, economic parameters and financial aspects as possible, and in order to increase real applicability to the context of globalization.

References	No. of	No. of	No. of	No. of	No. of	No. of test	Proposed	Compared	Max					
	products	suppliers	plants	DC/warehouses	retailers/customers	problems	method	with	GAP					
Qu et al. [19]	15-20	7	1	NA	NA	8	Heuristic	NA	NA					
Sabri and Beamon [26]	2	5	1-3	1-4	5	5	LINGO	NA	NA					
Jayaraman and Pirkul [24]	10	1-2	3-10	4-15	10-20	13	LR	LINGO	1.06%					
Hwang [29]	1	NA	4	10-99	NA	4	GA	Heuristic	20.41%					
Syarif et al. [8]	1	3-20	6-15	8-12	50-100	4	GA	LINDO	3.72%					
Zhou et al. [20]	1	NA	NA	3-10	30-100	8	GA	Heuristic	39.36%					
Syam [39]	1	10-100	2-20	NA	NA	30	LR	SA	7.75%					
Jang et al. [25]	10	NA	5-15	10-20	10	9	LR	CPLEX	4.1%					
Wang et al. [40]	2	NA	2	2	NA	1	CPLEX	NA	NA					
Jayaraman and Ross [33]	2-3	NA	5	10-15	30-75	8	SA	LINGO	4%					
Miranda and Garrido [21]	1	NA	10	20	NA	25	LR	LINGO	1.55%					
Melachrinoudis et al. [41]	1	NA	1	21	281	1	LINGO	NA	NA					
Altıparmak et al. [27]	1	5	3-8	6-20	63	5	GA	SA	5%					
Amiri [42]	1	NA	10-20	10-30	100-500	28	LR	CPLEX	11.54%					
Farahani and Elahipanah [34]	2-8	NA	2-8	2-15	4-60	9	GA	LINGO	4.7%					
Altıparmak et al. [9]	2-3	2	2-25	5-50	10-300	16	LR, GA, SA	CPLEX	12.92%					
Lee et al. [43]	1	3-8	2-3	2-3	3-8	5	LR	Xpress-MP	0%					
Pishvaee and Rabbani [22]	1	NA	5-40	15-70	10-100	5	Heuristic	LINGO	3.7%					
Babazadeh et al. [35]	1	NA	5-10	8-10	10-15	2	CPLEX	NA	NA					
Paksoy et al. [11]	1	5-35	3-6	3-7	4-28	8	LINDO	NA	NA					
Badri et al. [32]	5-15	5-35	5-20	5-22	10-120	10	LR	CPLEX	18.48%					
Benyoucef et al. [28]	1	NA	3-30	10-160	NA	30	LR	CPLEX	8.1%					
Hamta et al. [23]	7-10	NA	4-20	6-22	6-25	10	SAA	CPLEX	0.4%					
Cheraghi et al. [44]	1	4-8	3-5	3-5	3-6	3	RO	NA	NA					
Chiadamrong and Piyathanavong [45]	1	4	4	4	4	1	SOM	NA	NA					
Proposed study	1	4-302	2-151	2-151	4-302	450	GA, HHA	CPLEX	17.11%					

Table 2: Forward SCND problems in the literature.

LR: Lagrangian relaxation, GA: Genetic algorithm, SA: Simulated annealing, SAA: Sample average approximation, RO: Robust optimization, SOM: Simulation based optimization model, HHA: Hybrid heuristic approach.

According to 248 forward SCND test problems in Table 2, following findings can be highlighted;

- Minimization of shipping and fixed costs is the most common objective function,
- Mixed integer programming is the main solution approach,
- While small size test problems are solved by either CPLEX or LINGO, medium and large size test problems are tackled by meta-heuristic approaches,
- Each paper generates the test problems on its own rather than a common test problem which can be used for comparison.

Unfortunately, test problems generated by the researchers in Table 2 are inaccessible.

3 Forward supply Chain network design problems

In this section, three forward supply chain network models, each with different number of echelons are presented. While the largest forward supply chain network model (i.e., fourechelon) consists of suppliers, plants, distribution centers (DC), retailers and customers, two echelon network includes suppliers, plants and customers as shown in Figure 2.

3.1 Two echelon forward SCND problem

Let *S*, *P* and *D* denote the set of suppliers, plants, and distribution centers, respectively. Two echelon SCN consists of $G^{two} = (N^{two}, A^{two})$, where $N^{two} = \{S \cup P \cup D\}$ is the set of nodes and $A^{two} = \{(i, j, k) | (i \in S, j \in P) \cup (j \in P, k \in D)\}$ is the sets of arcs. The suppliers are companies from which raw materials are purchased. There are vehicles transporting the raw materials to potential plants. The manufacturing plant is the site where the products are produced and some of the plants are not opened due to fixed costs. Distribution centers are the demand points that need to be satisfied. It is noted that all parameters and variables of the three models are given in Appendix A.

The formulation of the two-echelon mathematical model is given as follows:

$$Min\left(\sum_{s\in S}\sum_{p\in p}X_{sp}Di_{sp}t + \sum_{p\in P}\sum_{d\in D}Y_{pd}Di_{pd}t\right) + \left(\sum_{p\in P}\Delta_p FC_p\right)$$
(1)

Subject to

$$\sum_{p \in P} X_{sp} \le Ca_s \quad \forall \ s \in S \tag{2}$$

$$\sum_{c \in C} Y_{pd} \le Ca_p \Delta_p \qquad \forall \ p \in P \tag{3}$$

$$\sum_{p \in P} Y_{pd} = De_d \quad \forall \ d \in D \tag{4}$$

$$\sum_{p \in P} \Delta_p \le MaxP \tag{5}$$

$$\sum_{s \in S} X_{sp} - \sum_{d \in D} Y_{pd} = 0 \quad \forall \ p \in P$$
(6)

$$X_{sp}, Y_{pd} \ge 0 \qquad \forall s \in S, p \in P \text{ and } d \in D$$
(7)

$$\Delta_p \in \{0, 1\} \qquad \forall \ p \in P \tag{8}$$

The objective function has two components (Eq. 1). While the first component represents the cost of transportation on each arc of the network, the second component stands for the fixed costs associated with locating the plants.

Constraints (2) and (3) mean that the production and transportation amount cannot exceed the capacity of suppliers and potential plants, respectively. Constraints (4) ensure that demand of each distribution center must fully be met. Constraints (5) limit the number of plants that can be opened. Constraints (6) are the balance equation: the quantities that enter plants must be equal to the quantities of products that leave the plants. Constraints (7) enforce the non-negativity restriction on the decision variables. Finally, Constraints (8) are the integrality enforcements on binary variable Δ_p .



Figure 2: Forward supply chain networks with different echelons.

3.2 Three echelon forward SCND problem

Let *S*, *P*, *D*, and *R* denote the set of suppliers, plants, distribution centers, and retailers, respectively. Three echelon SCN consists of $G^{three} = (N^{three}, A^{three})$, where $N^{three} = \{S \cup P \cup D \cup R\}$ is the set of nodes and $A^{three} = \{(i, j, k, l) | (i \in S, j \in P) \cup (j \in P, k \in D) \cup (k \in D, l \in R)\}$ is the sets of arcs. Raw materials are shipped from suppliers to potential plants for production. Products are transported from plants to the distribution centers, where the products are distributed to the retailers. Some of the plants and distribution centers may not be opened depending on fixed costs.

The formulation of the three-echelon mathematical model is given as follows:

$$Min \left(\sum_{s \in S} \sum_{p \in p} X_{sp} Di_{sp} t + \sum_{p \in P} \sum_{d \in D} Y_{pd} Di_{pd} t + \sum_{d \in D} \sum_{r \in R} Z_{dr} Di_{dr} t\right) + \left(\sum_{p \in P} \Delta_p F C_p + \sum_{d \in D} \Gamma_d F C_d\right)$$

$$(9)$$

Subject to

Constraints (2), (3), (5), (6), (7), (8) and

$$\sum_{r \in R} Z_{dr} \le C a_d \Gamma_d \ \forall \ d \in D \tag{10}$$

$$\sum_{d \in D} Z_{dr} = De_r \quad \forall r \in R \tag{11}$$

$$\sum_{d\in D} \Gamma_d \le MaxD \tag{12}$$

$$\sum_{p \in P} Y_{pd} - \sum_{r \in R} Z_{dr} = 0 \quad \forall \ d \in D$$
(13)

$$Z_{dr} \ge 0 \qquad \forall \ d \in D \ and \ r \in R \tag{14}$$

$$\Gamma_d \in \{0, 1\} \qquad \forall \ d \in D \tag{15}$$

The objective function has two components (Eq. 9). The first component represents the cost of transportation on each arc of the network (i.e., between suppliers-plants-distribution centers and retailers). The second component represents the fixed costs associated with locating the plants and distribution centers.

Constraints (10) guarantee that the production and transportation amount must not exceed the capacity of distribution centers. Constraints (11) ensure that demands of each retailer must fully be met. Constraints (12) limit the number of distribution centers that can be opened. Constraints (13) are the balance equation: the quantities that enter distribution centers must be equal to the quantity of products that leave the distribution centers. Constraints (14) enforce the non-negativity restriction on the decision variable (Z_{dr}). Finally, Constraints (15) are the integrality enforcements on binary variable Γ_d .

3.3 Four echelon forward SCND problem

Let *S*, *P*, *D*, *R*, and *C* denote the set of suppliers, plants, distribution centers, retailers and customers, respectively. Four echelon SCN consists of $G^{four} = (N^{four}, A^{four})$, where $N^{four} = \{S \cup P \cup D \cup R \cup C\}$ is the set of nodes and $A^{four} = \{(i, j, k, l, m) | (i \in S, j \in P) \cup (j \in P, k \in D) \cup (k \in D, l \in R) \cup (l \in R, m \in C)\}$ is the sets of arcs. Raw materials are shipped

from suppliers to plants for production. Products are transported from plants to the distribution centers where the products are distributed to the retailers. At last step, customers' demands are met by retailers. Some of the plants, distribution centers and retailers may not be opened due to fixed costs.

The mathematical formulation of the three-echelon model is as follows:

 $\begin{aligned} &Min\left(\sum_{s\in S}\sum_{p\in p}X_{sp}Di_{sp}t+\sum_{p\in P}\sum_{d\in D}Y_{pd}Di_{pd}t+\sum_{d\in D}\sum_{r\in R}Z_{dr}Di_{dr}t+\sum_{r\in R}\sum_{c\in C}W_{rc}Di_{rc}t\right)+\left(\sum_{p\in P}\Delta_{p}FC_{p}+\sum_{d\in D}\Gamma_{d}FC_{d}+\sum_{r\in R}\Psi_{r}FC_{r}\right) (16)\\ &\text{Subject to} \end{aligned}$

Constraints (2), (3), (5), (6), (10), (12), (13), (14), (15) and

$$\sum_{c \in C} W_{rc} \le C a_r \Psi_r \qquad \forall r \in R \tag{17}$$

$$\sum_{r \in R} W_{rc} = De_c \quad \forall \ c \in C \tag{18}$$

$$\sum_{r\in R} \Psi_r \le MaxR \tag{19}$$

$$\sum_{r \in R} Z_{dr} - \sum_{c \in C} W_{rc} = 0 \quad \forall r \in R$$
(20)

$$W_{rc} \ge 0 \quad \forall r \in R \text{ and } c \in C$$
(21)

$$\Psi_r \in \{0, 1\} \qquad \forall r \in R \tag{22}$$

The objective function has two components (Eq. 16). The first component represents the cost of transportation on each arc of the network (between suppliers-plants-distribution centersretailers and customers). The second component represents the fixed costs associated with locating the plants, distribution centers and retailers.

Constraints (17) mean that the production and transportation quantity must not exceed the capacity of retailers. Constraints (18) ensure that demand of each customer must fully be met. Constraints (19) limit the number of retailers that can be opened. Constraints (20) are the balance equation: the quantities that enter retailers must be equal to the quantity of products that leave the retailers. Constraints (21) enforce the non-negativity restriction on the decision variable (W_{rc}). Lastly, Constraints (22) are the integrality enforcement on the binary variable Ψ_r .

3.4 Generation of benchmark instances

This section describes how the instances in the proposed SCND problem benchmark are generated. 450 different benchmark instances ranging from small to large size for forward SCND problems with two, three and four-echelon are generated in this study. As is the case in almost all the existing instances, the distances between all type problems are two-dimensional Euclidean. All facilities in two, three and four echelon structures have integer coordinates corresponding to points in a [0; 500]. Shipping cost (t) is set 0.05 monetary units. Fixed cost of potential plants, distribution centers and retailers in all network structures have integer coordinates corresponding to points in a [2750; 3250]. Maximum available numbers of plants, distribution centers and retailers with interval values are given in Table 3.

We randomly generate the data based on uniform distribution. For further details about the benchmark instances, we refer the reader to the Appendix B. All instances are available on the supply chain network design problem web page (scndp.info).

	Two-Echolon Structuro											
	Parameters	Integer Interval										
Ca_s	Capacities of suppliers	950-1000										
Ca_p	Capacities of plants	2500-3000										
De_d	Demands of distribution centers	800-850										
Three-Echelon Structure												
Parameters Integer Interva												
Ca_s	Capacities of suppliers	950-1000										
Ca_p	Capacities of plants	2500-3000										
Ca_d	Capacities of distribution centers	2500-3000										
De_r	Demands of retailers	800-850										
	Four-Echelon Structur	re										
	Parameters	Integer Interval										
Ca _s	Capacities of suppliers	950-1000										
Ca_p	Capacities of plants	2500-3000										
Ca_d	Capacities of distribution centers	2500-3000										
Ca_r	Capacities of retailers	2500-3000										
De_c	Demands of customers	800-850										

Table 3: Parameter intervals used to generate different problem sizes.

4 Description of the Genetic algorithm

This section describes the proposed GA to solve the generated forward SCND instances. The GA builds on several powerful evolutionary based meta-heuristic algorithms (see [9],[27],[46]-[49).

The general scheme of the GA is shown in Algorithm 1. The initialization procedure (Line 1) is used to generate initial population. Two parents are selected (Line 3) for a crossover operation through a binary tournament process in order to creates a new offspring C (Line 4). The mutation technique is used on the offspring C (Line 5). Then, created offspring (offspring C) is added into the population (Line 6). As new offspring are added, the population size n_a , which is limited by n_{p+n_0} , changes over the iterations. The constant n_p denotes the size of the population initialized at the beginning of the algorithm and the constant n_0 is the maximum allowable number of offspring that can be inserted into the population. If the population size n_a reaches $n_{p+}n_o$ at any iteration, then a survivor selection mechanism is applied (Line 7). When the number of Φ iterations without improvement in the incumbent solution is reached, the GA terminates (Line 8).

Algorithm 1: The general framework of the GA.

- 1 Initialization: Initialize a population with size n_p
- 2 **while** number of iterations without improvement < Φ
- 3 Parent selection: select parent solutions *P*₁ and *P*₂
- 4 Crossover: generate offspring *C* from *P*₁ and *P*₂
- 5 Mutation: diversify the offspring *C*
- 6 Add offspring *C* to the population
- 7 Survivor selection: if the population size n_a reaches $n_p + n_o$, then select survivors
- 8 end while
- 9 Return best feasible solution

The rest of the part presents basic elements of the GA. Section 4.1 offers representation and evaluation of the results. The initialization procedure is given Section 4.2 in detail. The selection of parent solutions and a segment-based crossover operator are then described in Section 4.3. The mutation procedure is presented in Section 4.4. Lastly, Section 4.5 presents the survivor selection mechanism.

4.1 Representation and evaluation

The priority-based encoding of Gen et al. is adapted [46] for the problems to represent our solutions within the population. For two-echelon SCND problem, the result includes of priorities of first echelon, containing first-level facilities (FL) and second-level facilities (SL), and second echelon including SL and third-level facilities (TL). Priority-based encoding for two-echelon SCND problem is illustrated in Figure 3.

First Echelon								Second Echelon											
2	7	4	6	10	3	1	5	8	9	1	3	6	7	4	8	5	9	2	10
	Fir	st Le	vel			Seco	ond L	evel		Second Level				Third Level					

Figure 3: The representation of the priority-based encoding.

Each solution consists of a single-dimensional array and numbers representing the priority of each node. The total amount of echelons (|FL|+2*|SL|+|TL|) equals to the length of encoding. The transportation tree on a given solution is generated by sequential arc appending between levels. In accordance with priority-based encoding, we first consider the highest priority of TL, and we then open a SL to satisfy its demand. Depending on the selected TL, a SL is decided with taking into account minimum transportation cost and an arc between them. This process is iteratively applied to all facilities until all demands are satisfied. For three-echelon and fourechelon SCND problems, we applied same procedure with adapting the representation to each problem type. The fitness value of each solution is calculated by using the objective function of the considered problem (minimization of total transportation and fixed costs). These fitness values are used to select survivors during the algorithmic iterations. For further implementation details on representation and evaluation section, the reader is referred to Gen et al. [46].

4.2 Initialization, parent selection and crossover

We randomly generate the initial population. For example, we consider a two-echelon SCND problem in Figure 3. First echelon includes first-level and second-level facilities, where |FL|=5 and |SL|=5. The total length of the first-echelon is equal to |FL|+|SL|=10 such that a priority is assigned to each node within the range of 1 and 10.

Two parents are selected with use of the binary tournament for generate offspring C. The technique selects randomly two different individuals from the population. After that, it preserves the one of them having the best fitness value. Following the parent selection phase, two parents undergo the segment-based crossover operator, which is relied upon uniform crossover and tends to keep good gene segments of both parents. Representation of this operator is shown in Figure 4. Each echelon of offspring C is selected at random with equal probability over echelons of parents. These crossover operators use a binary mask where its length is equal to the number of echelons. Binary variables 0 and 1 are used to transfer the genetic materials from parents to offspring C. Each echelon of offspring C randomly takes 0 or 1 values, through which 0 implies the first parent and 1 implies the second parent transferring its genetic materials to the offspring C.



operator.

4.3 Mutation

The effective controlling of results plays a important role in population variety. Therefore, a segment-based mutation operator after crossover, which is represented in Figure 5 has applied in order to improve the performance of the GA. In this step, selected two nodes are relocated in order to increase to the diversification of the results. First, an echelon is randomly selected with using a binary mask as in the crossover operator. Then, two nodes are randomly selected from the same echelon. Finally, these are exchanged by using swap method according to their priorities.



operator.

4.4 Survivor selection

Avoiding premature convergence is a key challenge in population-based meta-heuristics. Population diversity or searching varied area in the solution space can help find best solution or optimal during the algorithm. To tackle with this issue, we used survivor selection method (see [48]), which intends to provide the diversity of the population and preserve the best solutions. Initially, the initial population is generated with the size of n_p , and then at each iteration a generated offspring is inserted into to the population after each iteration. The maximum number of allowable offspring in the population is denoted by n_o . When total population size n_a reaches the maximum limit $n_p + n_o$, the survivor selection mechanism works to select offspring for next generation. On other words, the technique, afterward, elects n_p and separate n_o individuals from the population. The rest of n_0 individuals are selected based on their fitness. In this way, best individuals are protected.

5 Description of the hybrid heuristic algorithm

We develop a two-phase HHA based on the principles of heuristics and integer programming. The problem is divided into two sub-problems, which are finding feasible location plant (plant, distribution center and retailer) and transportation on each arc of the network (between suppliers-plants-distribution centers-retailers and customers). A constructive heuristic is used first generates feasible solutions for finding feasible location in order to meet customer demands. Second subproblem is then solved to optimality with using first subproblem solution by an integer programming solver. The decision variables in the sub-problems are the same as those found within the original formulation.

5.1 Constructive heuristic technique

To obtain optimal solution of the problem is not easy because of dependencies between finding feasible facility location and design of the network configuration. Therefore, the first part of the problem that is location of facilities (plants, distribution centers, retailers, collection centers, disassembly centers etc.) to be opened is determined by the proposed heuristic algorithm.

The first algorithm, constructive heuristic, builds the solution based on the fixed costs (associated with locating the plants, distribution centers and retailers) and costumer demand. First of all, two lists, which are UnexploredNodes, and ExploredNodes list are built to start solution. In the beginning, while UnexploredNodes list includes all potential facility in order to assign solution, *ExploredNodes* is empty list. When a potential facility selects, that facility moves to *ExploredNodes* list. Second, the heuristic technique produces root nodes from lists of unexplored nodes at the first level. Then, descendant nodes are generated for each root nodes. If capacity of nodes (root and descents nodes) is greater than total customer demand, these nodes are transferred to list of Solutions. If the size of the list is larger than predetermined size $(2^{*}\beta)$, certain solutions are selected according to routhwhell selection method to BestSolution list up to the number of β solutions. The objective function, fixed costs associated with locating the plants, is used in routhwhell selection method. The general structure of the constructive heuristic algorithm is shown in Algorithm 2.

Algorithm 2: The general framework of the constructive

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- 1. Set Solutions=null and BestSolutions = null
- 2. Build two lists UnexploredNodes and ExploredNodes
- 3. Build an empty solution and add it to UnexploredNodes
- 4. **For** iter = 1,..., MaxIter (increasing iter by 1)
- 5. Assign the all potential facility in ExploredNodes and select it as Parent
- 6. For each node
- 7. Update lists of UnexploredNodes
- 8. Create a descentes nodes from the parent

9. **if** capacity of nodes (root and descentes nodes) >= Total customer demands

- 10. Update Solutions list
- 11. end **if**
- 12. **if** size of Solution ≥2 ∗β
- 13. Select the solutions according to Routhwhell selection from list of *Solution and update BestSolutions list*
- 14.End if
- 15.End For
- 16. End For
- 17. Output: BestSolutions

5.2 Integer programming procedure

In this section, after generating initial solution from constructive heuristic, a new procedure based on mathematical approach is proposed. In the proposed model, binary variables of $\Delta_p, \Gamma_d, \Psi_r$ are transformed to parameters. Thus, fixed costs associated with locating the plants in the objective function is removed and new objective function for all echelons models are given as follows:

$$\operatorname{Min} \sum_{s \in S} \sum_{p \in p} X_{sp} \operatorname{Di}_{sp} t + \sum_{p \in P} \sum_{d \in D} Y_{pd} \operatorname{Di}_{pd} t$$
(23)

$$\begin{array}{l} \text{Min} \ \sum_{s \in S} \sum_{p \in p} X_{sp} \text{Di}_{sp} t + \sum_{p \in P} \sum_{d \in D} Y_{pd} \text{Di}_{pd} t \\ + \sum_{d \in D} \sum_{r \in R} Z_{dr} \text{Di}_{dr} t \end{array}$$

$$\operatorname{Min} \sum_{s \in S} \sum_{p \in p} X_{sp} \operatorname{Di}_{sp} t + \sum_{p \in P} \sum_{d \in D} Y_{pd} \operatorname{Di}_{pd} t + \sum_{d \in D} \sum_{r \in R} Z_{dr} \operatorname{Di}_{dr} t + \sum_{r \in R} \sum_{c \in C} W_{rc} \operatorname{Di}_{rc} t$$
(25)

The objective is to minimize the cost of transportation on each arc of the network. After determination of $\Delta_{\rm p}$, Γ_d , Ψ_r as parameters, certain constraints are eliminated from the mathematical model. The modifications in all mathematical models are given follows.

In two echelons model: The variable of $\Delta_{\rm p}$ is modified as a parameter, which is obtained from the proposed heuristic algorithm in the Constraints (3). Also, the Constraints (5) are eliminated from model.

In three echelons model: The variables of Δ_p , Γ_d are changed as parameters in Constraints (3) and (10) respectively. In addition, Constraints (5) and (12) are removed from the model.

In four echelons model: Similarly in the previous models, the variables of $\Delta_{\rm p}$, Γ_d , Ψ_r are modified as parameters in the Constraints (3), (10), and (17), respectively. Constraints (5), (12) and (19) are also eliminated from model.

6 Comparative results

In this section, we present the comparative results in order to show the performance of the formulations, the GA and the HHA. All computational experiments are conducted on a server with one gigabyte RAM and Intel Xeon 2.6 GHz processor. We used CPLEX 12.5 with its default settings as the optimizer to solve the integer programming formulations. The GA is coded in C++ and HHA is coded in MATLAB. Maximum allowable computational time is set three hours for each instance in the mathematical formulation solutions. For the GA and the HHA, ten separate runs are performed for each instance and the best one is reported.

Three different network structures (i.e., two, three and four echelons) are solved to evaluate the performance of the formulations, the proposed heuristic algorithms. Summary information about solutions obtained by GAMS, GA and HHA are given in Table 4. All detailed solutions of 450 instances can be found on website scndp.info.

The results show that the GA yields optimal solutions for 21, 16 and 6 test instances out of 150 for two, three and four echelon configurations, respectively. On the other hand, the HHA finds also optimal solution for 32, 20, and 11 problems for the configuration, respectively. In total, 308 of 450 test problems are solved optimality by CPLEX. However, no solutions are obtained in 109 test problems. CPLEX finds a feasible solution within three hours-time limit for the rest 33 the test problems. While the GA finds optimal solutions in 43 test problems, HHA produces optimal solution in 63 test problems. Both algorithms yield good quality solutions in the remaining test problems within a reasonable computation time as well. Expectedly, increasing the size of the network also increases the computation time of the problem. Solution time dramatically increases when the size of the network grows. As can be seen from Table 4, while average CPU time is 386.47 sec. for two echelon network, it jumps to 6266.22 sec., which is 16 times higher than that for four echelon network.

Detailed average results are given in Tables 5-7. It is shown that GA and HHA produce optimal/feasible solutions in all the test problems. For two-echelon test problems, both algorithms are capable of finding the optimal solution in small sizes but the HHA shows better performance than the GA. However, the possibility of finding optimal results decreases in larger echelon structures in the both algorithm. The results clearly indicate that the GA and HHA require quite less computational time and memory than does CPLEX (Tables 5-7). Numbers in bold indicates that HHA performs better than GA in most of the test problems. From Tables 6 and 7, three and four-echelon networks, involving more than hundred facilities cannot even produce feasible solutions within the given time limit (see Figure 6). It must be noted that the capacity and demand values of each problem are not investigated to see the effects on solution time.

Tast Groups	CPLEX											
rest droups	Optimal	Feasible	NA	Average Time(sec.)								
Two Echelon	149	1	0	386.47	_							
Three Echelon	93	7	50	4460.10								
Four Echelon	66	25	59	6266.22								
	Optimal	Feasible	NA	Average Time(sec.)	Average Gap (%) ^a							
Two Echelon	21	129	0	17.60	2.96							
Three Echelon	16	134	0	92.81	3.23							
Four Echelon	6	144	0	104.90	2.59							
				ННА								
	Optimal	Feasible	NA	Average Time(sec.)	Average Gap (%) ^b							
Two Echelon	32	118	0	21.80	2.47							
Three Echelon	20	130	0	111.21	2.95							
Four Echelon	11	139	0	223.45	2.22							

Table 4: A summary of solution obtained by CPLEX, GA and HHA.

^a(GA-GAMS)/GAMS×100; ^b(HHA-GAMS)/GAMS×100.

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	CPL	EX	0	GA	1		ННА	
Instance set	Total Cost	Time (s)	Total Cost	Time (s)	Gap (%)	Total Cost	Time (s)	Gap (%)
2Ech F1 (1-10)	122374.79	0.01	122374.79	1.60	0.00	122374.79	2.60	0.00
2Ech_F2 (11-20)	213572.04	0.16	213572.04	1.78	0.00	213572.04	3.78	0.00
2Ech F3 (21-30)	298143.84	0.43	299411.03	2.27	0.43	298143.84	3.27	0.00
2Ech F4 (31-40)	344712.50	1.21	352132.69	3.24	2.15	348754.50	4.87	1.17
2Ech F5 (41-50)	397433.25	3.12	407892.02	4.43	2.63	409878.25	5.02	3.13
2Ech F6 (51-60)	450919.48	6.15	462753.30	5.48	2.62	463456.81	5.45	2.78
2Ech F7 (61-70)	501853.49	15.40	517483.93	7.67	3.11	516878.72	6.90	2.99
2Ech F8 (71-80)	534133.54	25.76	568344.99	9.06	6.41	553876.67	6.45	3.70
2Ech F9 (81-90)	584866.67	58.18	608512.10	11.02	4.04	593453.54	7.25	1.47
2Ech F10 (91-100)	624841.59	116.18	650806.72	13.05	4.16	643334.25	8.30	2.96
2Ech F11 (101-110)	659888.85	293.50	691024.20	18.23	4.72	674563.32	10.34	2.22
2Ech F12 (111-120)	697923.56	267.47	730800.37	21.58	4.71	724563.46	11.30	3.82
2Ech F13 (121-130)	728565.32	671.41	761192.41	36.58	4.48	742323.64	14.45	1.89
2Ech F14 (131-140)	787289.91	1418.81	824241 77	48.96	4 69	810345 87	26.94	2.93
2Ech F15 (141-150)	823307.80	2916.86	862463.40	79.00	4.76	854356.67	52.34	3.77
		bla (. Awara	go nogulta of the		est problems		02.01	0177
			ige results of thi		est problems		шца	
Instance set	Total Cost	A Time (s)	Total Cost	GA Time (s)	Gan (%)	Total Cost	Time (s)	Gan (%)
3Ech F1 (1-10)	188409.08	0.03	188409.08	2.01	0.00	188409.08	2.09	0.00
3Ech F2 (11-20)	330404.62	0.44	330588.42	2.01	0.05	330404.62	3.03	0.00
3Ech F3 (21-30)	442498.54	2.59	450293.09	4.24	1.76	448939.56	5.03	1.45
3Ech_F4 (31-40)	552731.83	7.57	568136.48	5.46	2.78	567854.42	6.00	2.73
3Ech_F5 (41-50)	627773.99	20.85	647751.95	7.06	3.18	639864.78	7.08	1.92
3Ech_F6 (51-60)	690874.80	66.72	718016.64	8.88	3.92	709345.62	11.03	2.67
3Ech_F7 (61-70)	787846.31	276.00	823966.76	15.40	4.58	813464.87	20.17	3.25
3Ech_F8 (71-80)	855301.36	1519.48	903561.68	29.55	5.64	897844.12	29.75	4.97
3Ech_F9 (81-90)	948197.90	4038.77	1002084.67	73.25	5.68	995643.25	53.45	5.00
3Ech_F10 (91-100)	1006877.01	6969.03	1071230.95	125.13	6.39	1065984.40	110.24	5.87
3Ech_F11 (101-110)	NA	NA	1127126.23	175.87	NA	1039125.50	174.70	NA
3Ech_F12 (111-120)	NA	NA	1208267.74	204.79	NA	1128964.75	210.25	NA
3Ech_F13 (121-130)	NA	NA	1273912.63	226.97	NA	1263456.56	227.30	NA
3Ech F14 (131-140)	NA	NA	1354553.31	243.31	NA	1294535.87	251.30	NA
3Ech F15 (141-150)	NA	NA	1416876.41	268.21	NA	1405743.46	260.74	NA
	Т	able 7. Aver	age results of fo	ur echelon te	est problems			
		CPLEX	age 100 and 01 10		GA			ННА
Instance set	Total Cost	Time (s)	Total Cost	Time (s)	Gan (%)	Total Cost	Time (s)	Gan (%)
4Ech E1 (1-10)	261446 77	0.05	261776.77	1 52	0.12	261446 77	2.03	0.00
4 Ech F2 (11-20)	446461 55	1 48	455425.90	1.52	2.00	447212.60	3.04	0.00
4Fch F3 (21-30)	593410.62	5.18	611467 39	3.61	3.04	609842.50	4 60	2.76
4Ech F4 (31-40)	722069.96	23.84	739428.04	5 56	2 40	737843 76	6 4 0	2.18
4Fch F5 (41-50)	854909.84	235 70	87490984	11.00	2.10	866905 32	10 50	1 40
4Ech F6 (51-60)	955781.62	2475.83	983781.68	17.24	2.33	979842.45	22.40	2.51
4Ech F7 (61-70)	1061234.46	5672.01	1238973 74	31 58	16.74	1213563.87	30.60	14 35
4Ech F8 (71-80)	1154708 33	9158 50	1423015.61	64 42	23.73	1352343 65	60.65	17 11
4Ech F9 (81-90)	1272519 58	10800.00	1402673.84	111 72	10.22	1394564 50	110 30	950
4Fch F10 (91-100)	1375804.21	10800.00	1684762.24	130.45	20.22	1502425 90	125.50	0.07
4Fch F11 (101-110)	1373004.31 NA	N A	2521982.62	167 4.4	22.43 NA	2522426 79	165 70	λ.2.7 Ν.Δ
4Fch F12 (111-120)	N A	NA NA	2729208 1.1	189.77	N A	2703445 40	185.60	NΔ
4Ech F13 (121-120)	NΔ	NΔ	2981610.44	222.04	NΔ	2974562 21	225 00	NΔ
4Ech F14 (131-140)	NΔ	NΔ	3170228 58	261 55	NΔ	3164635.90	260 40	NΔ
4Ech_F15 (141-150)	NA	NA	3405414.13	354.40	NA	3304567.50	350.45	NA



Figure 6: Comparisons of GA and HHA in terms of average total cost.

Results show that the gap between CPLEX and GA-HHA in three different network structures. As is clear from mentioned tables, the maximum gap interval is observed in four echelon test problems, minimum gap interval is observed in two echelon test problems.

In general, the results reveal that the gaps with respect to solution quality go between 0.00 and 23.23% for GA, and between 0.00 and 17.11% for HHA. Thus, the proposed HHA and GA perform very well in terms of quality of solutions and computational time.

Figure 6 indicates that HHA provides less total cost than GA in all test problem types. Average gap values between GA and HHA are also shown within Figure 6. According to this, average gap between GA and HHA is increased from 1.04% to 1.92% for small (two echelons) and large (four echelons) size problems, respectively.

7 Conclusions

In this paper, we have studied different scenarios of the wellknown forward supply chain network design (SCND) problem where two, three and four echelons are taken into account. Two-echelon SCND is composed of suppliers, production plants and distribution centers. Three and four-echelon SCND problems are extensions of the two-echelon form by adding retailer and customer, respectively. We have formulated each problem with mixed integer programming formulation. Since the problem belongs to NP-Hard problem class, mathematical formulations show poor performance as the number of echelon increases. We therefore develop two heuristic methods; GA and HHA. We compare the effectiveness of the proposed algorithms versus mathematical formulations.

Comparative results substantiate the outstanding performance of the GA and HHA. Based on the computational time measurement, GA and HHA show similar performance.

For future studies, proposed GA and HHA approaches can be compared with other heuristic and meta-heuristics techniques using current benchmark instances. Additionally, uncertainty of costs, demands and capacities can be considered in the model and new solution methodologies including uncertainty can be developed. Finally, similar benchmark instances can be developed for reverse and closed-loop supply chain networks.

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9 References

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Appendix A

Variables of two echelon forward SCND problem for quantities are as follows:

- $\begin{array}{ll} X_{sp} & \text{Amount shipped from supplier } s \text{ to plant } p; \ \forall \, s \in \\ S \text{ and } p \in P \end{array}$
- $Y_{pd} \qquad \text{Amount shipped from plant } p \text{ to distribution center d}; \\ \forall p \in P \text{ and } d \in D$
- Δ_p Binary variable which takes a value of 1 if plant p is open, 0, otherwise; $\forall p \in P$

The variable notations of two echelon forward SCND problem for model parameters are:

- Di_{sp} Distance between supplier *s* and potential plant *p*; $\forall s \in S$ and $p \in P$
- Di_{pd} Distance between potential plant p and distribution center d; $\forall p \in P$ and $d \in D$
- Ca_s Capacity of supplier $s; \forall s \in S$

- Ca_p Capacity of potential plant $p; \forall p \in P$
- De_d Demand of distribution center d; $\forall d \in D$
- *t* Unit shipping cost between facilities
- FC_p Fixed cost of opening plant $p; \forall p \in P$

MaxP Maximum available number of plants to be opened Variables of three echelon forward SCND problem for

quantities are as follows (in addition to the previous model):

- $\begin{aligned} Z_{dr} & \text{Amount shipped from distribution center } d \text{ to retailer} \\ r; \forall \ d \in D \text{ and } r \in R \end{aligned}$
- Γ_d Binary variable which takes value of 1 if distribution
center d is open. 0, otherwise $\forall d \in D$

The variable notations of three echelon forward SCND problem for model parameters are (in addition to the previous model):

- Di_{dr} Distance between potential distribution center d and retailer r; $\forall d \in D$ and $r \in R$
- Ca_d Capacity of potential distribution center d; $\forall d \in D$
- De_r Demand of retailer $r; \forall r \in R$
- FC_d Fixed cost of opening distribution center d; $\forall d \in D$
- MaxD Maximum available number of distribution centers to be opened

Variables of four echelon forward SCND problem for quantities are as follows (in addition to the previous models):

- $W_{rc} \qquad \text{Amount shipped from retailer } r \text{ to customer } c; \forall r \in R \text{ and } c \in C$
- Ψ_r Binary variable which takes value of 1 if retailer r is open. 0, otherwise $\forall c \in C$

The variable notations of four echelon forward SCND problem for model parameters are (in addition to the previous models):

- Di_{rc} Distance between potential retailer *r* and customer *c*; $\forall r \in R \text{ and } c \in C$
- *Ca*_r Capacity of potential retailer r; $\forall r \in R$
- De_c Demand of customer $c; \forall c \in C$
- *FC_r* Fixed cost of opening retailer r; $\forall r \in R$
- MaxR Maximum available number of distribution centers to be opened.

Appendix B

Tables A.1-A.3 present all 450 forward SCND instances (150 two-echelon, 150 three-echelon and 150 four-echelon) with number of facilities.

Table A: 1. Generated two echelons FSCN design instances with number of facili	ties.
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							ē							
S	Р	D	Test Problem	S	Р	D	Test Problem	S	Р	D	Test Problem	S	Р	D
4	2	4	2Ech_39	80	40	80	2Ech_77	156	78	156	2Ech_114	230	115	230
6	3	6	2Ech_40	82	41	82	2Ech_78	158	79	158	2Ech_115	232	116	232
8	4	8	2Ech_41	84	42	84	2Ech_79	160	80	160	2Ech_116	234	117	234
10	5	10	2Ech_42	86	43	86	2Ech_80	162	81	162	2Ech_117	236	118	236
12	6	12	2Ech_43	88	44	88	2Ech_81	164	82	164	2Ech_118	238	119	238
14	7	14	2Ech_44	90	45	90	2Ech_82	166	83	166	2Ech_119	240	120	240
16	8	16	2Ech_45	92	46	92	2Ech_83	168	84	168	2Ech_120	242	121	242
18	9	18	2Ech_46	94	47	94	2Ech_84	170	85	170	2Ech_121	244	122	244
	S 4 6 8 10 12 14 16 18	S P 4 2 6 3 8 4 10 5 12 6 14 7 16 8 18 9	S P D 4 2 4 6 3 6 8 4 8 10 5 10 12 6 12 14 7 14 16 8 16 18 9 18	S P D Test Problem 4 2 4 2Ech_39 6 3 6 2Ech_40 8 4 8 2Ech_41 10 5 10 2Ech_42 12 6 12 2Ech_43 14 7 14 2Ech_44 16 8 16 2Ech_45 18 9 18 2Ech_46	S P D Test Problem S 4 2 4 2Ech_39 80 6 3 6 2Ech_40 82 8 4 8 2Ech_41 84 10 5 10 2Ech_42 86 12 6 12 2Ech_43 88 14 7 14 2Ech_44 90 16 8 16 2Ech_45 92 18 9 18 2Ech_46 94	S P D Test Problem S P 4 2 4 2Ech_39 80 40 6 3 6 2Ech_40 82 41 8 4 8 2Ech_41 84 42 10 5 10 2Ech_42 86 43 12 6 12 2Ech_43 88 44 14 7 14 2Ech_44 90 45 16 8 16 2Ech_45 92 46 18 9 18 2Ech_46 94 47	S P D Test Problem S P D 4 2 4 2Ech_39 80 40 80 6 3 6 2Ech_40 82 41 82 8 4 8 2Ech_41 84 42 84 10 5 10 2Ech_42 86 43 86 12 6 12 2Ech_43 88 44 88 14 7 14 2Ech_44 90 45 90 16 8 16 2Ech_43 88 44 88 14 7 14 2Ech_43 90 45 90 16 8 16 2Ech_45 92 46 92 18 9 18 2Ech_46 94 47 94	S P D Test Problem S P D Test Problem 4 2 4 2Ech_39 80 40 80 2Ech_77 6 3 6 2Ech_40 82 41 82 2Ech_78 8 4 8 2Ech_41 84 42 84 2Ech_79 10 5 10 2Ech_42 86 43 86 2Ech_80 12 6 12 2Ech_43 88 44 88 2Ech_81 14 7 14 2Ech_44 90 45 90 2Ech_82 16 8 16 2Ech_45 92 46 92 2Ech_83 16 9 18 2Ech_46 94 47 94 2Ech_84	S P D Test Problem S P D Test Problem S 4 2 4 2Ech_39 80 40 80 2Ech_77 156 6 3 6 2Ech_40 82 41 82 2Ech_78 158 8 4 8 2Ech_41 84 42 84 2Ech_79 160 10 5 10 2Ech_42 86 43 86 2Ech_80 162 12 6 12 2Ech_43 88 44 88 2Ech_81 164 14 7 14 2Ech_44 90 45 90 2Ech_82 166 16 8 16 2Ech_45 92 46 92 2Ech_83 168 18 9 18 2Ech_46 94 47 94 2Ech_84 170	S P D Test Problem S P D Test Problem S P 4 2 4 2Ech_39 80 40 80 2Ech_77 156 78 6 3 6 2Ech_40 82 41 82 2Ech_78 158 79 8 4 8 2Ech_41 84 42 84 2Ech_79 160 80 10 5 10 2Ech_42 86 43 86 2Ech_80 162 81 12 6 12 2Ech_43 88 44 88 2Ech_81 164 82 14 7 14 2Ech_44 90 45 90 2Ech_82 166 83 16 8 16 2Ech_45 92 46 92 2Ech_83 168 84 18 9 18 2Ech_46 94 47 94 2Ech_84 170 85 <td>S P D Test Problem S P D Test Problem S P D 4 2 4 2Ech_39 80 40 80 2Ech_77 156 78 156 6 3 6 2Ech_40 82 41 82 2Ech_78 158 79 158 8 4 8 2Ech_41 84 42 84 2Ech_79 160 80 160 10 5 10 2Ech_42 86 43 86 2Ech_80 162 81 162 12 6 12 2Ech_43 88 44 88 2Ech_81 164 82 164 14 7 14 2Ech_44 90 45 90 2Ech_82 166 83 166 16 8 16 2Ech_45 92 46 92 2Ech_83 168 84 168 16 8</td> <td>S P D Test Problem S P D Test Problem 4 2 4 2Ech_39 80 40 80 2Ech_77 156 78 156 2Ech_114 6 3 6 2Ech_40 82 41 82 2Ech_78 158 79 158 2Ech_115 8 4 8 2Ech_79 160 80 160 2Ech_116 10 5 10 2Ech_42 86 43 86 2Ech_80 162 81 162 2Ech_117 12 6 12 2Ech_43 88 44 88 2Ech_81 164 82 <t< td=""><td>S P D Test Problem S 4 2 4 2Ech_39 80 40 80 2Ech_77 156 78 156 2Ech_114 230 6 3 6 2Ech_40 82 41 82 2Ech_78 158 79 158 2Ech_115 232 8 4 8 2Ech_41 84 42 84 2Ech_79 160 80 160 2Ech_116 234 10 5 10 2Ech_42 86 43 86 2Ech_80 162 81 162 2Ech_117 236 12 6 12 2Ech_43 88 44 88 2Ech_81 164 82 164 2Ech_118 238 14 7 14 2Ech_44</td><td>S P D Test Problem S P 4 2 4 2Ech_39 80 40 80 2Ech_77 156 78 156 2Ech_114 230 115 6 3 6 2Ech_40 82 41 82 2Ech_78 158 79 158 2Ech_115 232 116 8 4 8 2Ech_41 84 42 84 2Ech_79 160 80 160 2Ech_116 234 117 10 5 10 2Ech_42 86 43 86 2Ech_80 162 81 162 2Ech_117 236 118 12 6 12 2Ech_43 88 44 88 2Ech_81 164 82 164 2Ech_1118 238</td></t<></td>	S P D Test Problem S P D Test Problem S P D 4 2 4 2Ech_39 80 40 80 2Ech_77 156 78 156 6 3 6 2Ech_40 82 41 82 2Ech_78 158 79 158 8 4 8 2Ech_41 84 42 84 2Ech_79 160 80 160 10 5 10 2Ech_42 86 43 86 2Ech_80 162 81 162 12 6 12 2Ech_43 88 44 88 2Ech_81 164 82 164 14 7 14 2Ech_44 90 45 90 2Ech_82 166 83 166 16 8 16 2Ech_45 92 46 92 2Ech_83 168 84 168 16 8	S P D Test Problem S P D Test Problem S P D Test Problem S P D Test Problem S P D Test Problem S P D Test Problem S P D Test Problem S P D Test Problem S P D Test Problem 4 2 4 2Ech_39 80 40 80 2Ech_77 156 78 156 2Ech_114 6 3 6 2Ech_40 82 41 82 2Ech_78 158 79 158 2Ech_115 8 4 8 2Ech_79 160 80 160 2Ech_116 10 5 10 2Ech_42 86 43 86 2Ech_80 162 81 162 2Ech_117 12 6 12 2Ech_43 88 44 88 2Ech_81 164 82 <t< td=""><td>S P D Test Problem S 4 2 4 2Ech_39 80 40 80 2Ech_77 156 78 156 2Ech_114 230 6 3 6 2Ech_40 82 41 82 2Ech_78 158 79 158 2Ech_115 232 8 4 8 2Ech_41 84 42 84 2Ech_79 160 80 160 2Ech_116 234 10 5 10 2Ech_42 86 43 86 2Ech_80 162 81 162 2Ech_117 236 12 6 12 2Ech_43 88 44 88 2Ech_81 164 82 164 2Ech_118 238 14 7 14 2Ech_44</td><td>S P D Test Problem S P 4 2 4 2Ech_39 80 40 80 2Ech_77 156 78 156 2Ech_114 230 115 6 3 6 2Ech_40 82 41 82 2Ech_78 158 79 158 2Ech_115 232 116 8 4 8 2Ech_41 84 42 84 2Ech_79 160 80 160 2Ech_116 234 117 10 5 10 2Ech_42 86 43 86 2Ech_80 162 81 162 2Ech_117 236 118 12 6 12 2Ech_43 88 44 88 2Ech_81 164 82 164 2Ech_1118 238</td></t<>	S P D Test Problem S P D Test Problem S P D Test Problem S P D Test Problem S P D Test Problem S 4 2 4 2Ech_39 80 40 80 2Ech_77 156 78 156 2Ech_114 230 6 3 6 2Ech_40 82 41 82 2Ech_78 158 79 158 2Ech_115 232 8 4 8 2Ech_41 84 42 84 2Ech_79 160 80 160 2Ech_116 234 10 5 10 2Ech_42 86 43 86 2Ech_80 162 81 162 2Ech_117 236 12 6 12 2Ech_43 88 44 88 2Ech_81 164 82 164 2Ech_118 238 14 7 14 2Ech_44	S P D Test Problem S P D Test Problem S P D Test Problem S P D Test Problem S P D Test Problem S P 4 2 4 2Ech_39 80 40 80 2Ech_77 156 78 156 2Ech_114 230 115 6 3 6 2Ech_40 82 41 82 2Ech_78 158 79 158 2Ech_115 232 116 8 4 8 2Ech_41 84 42 84 2Ech_79 160 80 160 2Ech_116 234 117 10 5 10 2Ech_42 86 43 86 2Ech_80 162 81 162 2Ech_117 236 118 12 6 12 2Ech_43 88 44 88 2Ech_81 164 82 164 2Ech_1118 238

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							Table A	A: 1. Cont	•								
2Ech_9	20 10	20	2Ec	ch_47	96	48	96	2Ech_	85	172	86	172	2E	ch_122	246	123	246
2Ech_10	22 11	22	2Ec	ch_48	98	49	98	2Ech_	86	174	87	174	2E	ch_123	248	124	248
2Ech_11	24 12	24	2Ec	ch_49	100	50	100	2Ech_	87	176	88	176	2E	ch_124	250	125	250
2Ech_12	26 13	26	2Ec	ch_50	102	51	102	2Ech_	88	178	89	178	2E	ch_125	252	126	252
2Ech_13	28 14	28	2Ec	h_51	104	52	104	2Ech_	89	180	90	180	2E	ch_126	254	127	254
2Ech_14	30 15	30	2Ec	h_52	106	53	106	2Ech_	90	182	91	182	2E	ch_127	256	128	256
2Ech_15	32 16	32	2Ec		108	54	108	2Ech	91	184	92	184	2E	ch_128	258	129	258
2Ech 16	34 17	34	2Ec	- h 54	110	55	110	2Ech	92	186	93	186	2E	ch 129	260	130	260
2Ech 17	36 18	36	2Ec	- ch 55	112	56	112	2Ech	93	188	94	188	2E	_ ch 130	262	131	262
2Ech 18	38 19	38	2Ec	- ch 56	114	57	114	2Ech	94	190	95	190	2E	_ ch 131	264	132	264
2Ech 19	40 20	40	2Ec	- h 57	116	58	116	2Ech	95	192	96	192	2E	_ ch 132	266	133	266
2Ech 20	42 21	42	2Ec	- ch 58	118	59	118	2Ech	96	194	97	194	2E	_ ch 133	268	134	268
2Ech 21	44 22	44	2Ec	- h 59	120	60	120	2Ech	97	196	98	196	2E	_ ch 134	270	135	270
2Ech 22	46 23	46	2Ec	ch 60	122	61	122	2Ech	98	198	99	198	2E	ch 135	272	136	272
2Ech 23	48 24	48	2Ec	ch 61	124	62	124	2Ech	99	200	100	200	2E	ch 136	274	137	274
2Ech 24	50 25	50	2Ec	ch 62	126	63	126	2Ech 1	00	202	101	202	2E	ch 137	276	138	276
2Ech 25	52 26	52	2Ec	ch 63	128	64	128	2Ech	01	204	102	204	2E	ch 138	278	139	278
2Ech 26	54 27	54	2Ec	ch 64	130	65	130	2Ech	02	206	103	206	2E	ch 139	280	140	280
2Ech 27	56 28	56	2Ec	n_01	132	66	132	2Ech 1	03	208	104	208	2E	ch 140	282	141	282
2Ech 28	58 29	58	2Ec	n_00	134	67	134	2Ech_1	04	210	105	210	2E	ch 141	284	142	284
2Ech_20 2Ech_29	60 30	60	2Ec	n_00	136	68	136	2Ech_	05	212	106	212	2F	ch 142	286	143	286
2Ech_29	62 31	62	2EC	n_07	138	69	138	2Ech_	06	212	107	212	2E 2F	ch 143	288	144	288
2Ech_30	64 32	64	2EC 2EC	h 69	140	70	140	2 Ech	07	214	108	214	2E 2E	ch 144	200	145	200
2Ech_31	66 33	66	2E0	h 70	140	70	140	2Ech_	08	210	100	210	26	ch_{145}	290	146	290
2Ech_32	68 34	68	2EC 2EC	-11_70	144	72	144	2Ech	00	210	110	210	21	145	292	147	292
2Ech_33	70 35	70	2EC 2EC	h 72	146	72	146	2 Ech	10	220	111	220	2E 2E	ch_{147}	296	148	296
ZLCII_J4	/0 55	70	210		140		140		10	222	110	222	21		270	140	2,0
2Ech 25	72 36	72	260	-h 72	1/1.8	'/A.	1/1.8	2 Ech 1		///.		227	2 H	ch 148	748	17.4	700
2Ech_35 2Ech_36	72 36	72 74	2E0 2E0	ch_73	148 150	74	148 150	2Ech_2	11	224 226	112	224 226	2E 2E	ch_148	298	149	298 300
2Ech_35 2Ech_36 2Ech_37	72 36 74 37 76 38	72 74 76	2E0 2E0 2E0	ch_73 ch_74	148 150 152	74 75 76	148 150 152	2Ech_1 2Ech_1 2Ech_1	11	224 226 228	112 113 114	224 226 228	2E 2E 2E	ch_148 ch_149 ch_150	298 300 302	149 150 151	298 300 302
2Ech_35 2Ech_36 2Ech_37 2Ech_38	72 36 74 37 76 38 78 39	72 74 76 78	2E0 2E0 2E0 2E0	ch_73 ch_74 ch_75 ch_76	148 150 152 154	74 75 76 77	148 150 152 154	2Ech_2 2Ech_2 2Ech_2	11 12 13	224 226 228	112 113 114	224 226 228	2E 2E 2E	ch_148 ch_149 ch_150	298 300 302	149 150 151	298 300 302
2Ech_35 2Ech_36 2Ech_37 2Ech_38	72 36 74 37 76 38 78 39	72 74 76 78	2Ec 2Ec 2Ec 2Ec	ch_73 ch_74 ch_75 ch_76	148 150 152 154	74 75 76 77	148 150 152 154	2Ech_1 2Ech_1 2Ech_1	112	224 226 228	112 113 114	224 226 228	2E 2E 2E	ch_148 ch_149 ch_150	298 300 302	149 150 151	298 300 302
2Ech_35 2Ech_36 2Ech_37 2Ech_38	72 36 74 37 76 38 78 39 1	72 74 76 78 'able 2	2Ec 2Ec 2Ec 2Ec A: 2. Ger	ch_73 ch_74 ch_75 ch_76 nerate	148 150 152 154 ed three ec	74 75 76 77 chelo	148 150 152 154 ons FSC	2Ech_2 2Ech_2 2Ech_2 N design	instan	224 226 228 ces wit	112 113 114 th nun	224 226 228 nber o	2E 2E 2E f facili	ch_148 ch_149 ch_150 ities.	298 300 302	149 150 151	298 300 302
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem	72 36 74 37 76 38 78 39 1 S	72 74 76 78 Table 2 P	2Ec 2Ec 2Ec 2Ec A: 2. Ger D	ch_73 ch_74 ch_75 ch_76 nerate R	148 150 152 154 ed three ec Test Pro	74 75 76 77 chelc bler	148 150 152 154 ons FSC	2Ech_2 2Ech_2 2Ech_2 N design	111 12 13 instan D	224 226 228 ces wit	112 113 114 th nun Te	224 226 228 nber o	2E 2E 2E f facili	ich_148 ich_149 ich_150 ities.	298 300 302 P	149 150 151 D	298 300 302 R
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1	72 36 74 37 76 38 78 39 1 S 4	72 74 76 78 Sable 2 P 2	2Ec 2Ec 2Ec 2Ec A: 2. Ger D 2	ch_73 ch_74 ch_75 ch_76 nerate R 4	148 150 152 154 ed three ec Test Pro 3Ech_	74 75 76 77 chelo bler 51	148 150 152 154 ons FSC n S 10	2Ech_: 2Ech_: 2Ech_: N design 5 P 4 52	111 12 13 instan D 52	224 226 228 ces wit R 104	112 113 114 h num Te	224 226 228 nber o st Pro 3Ech_2	2E 2E 2E f facili blem	ities.	298 300 302 P 102	149 150 151 D 102	298 300 302 R 204
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2	72 36 74 37 76 38 78 39 1 5 4 6	72 74 76 78 Yable J P 2 3	2Ec 2Ec 2Ec 2Ec A: 2. Ger D 2 3	ch_73 ch_74 ch_75 ch_76 nerate R 4 6	148 150 152 154 ed three ec Test Pro 3Ech_ 3Ech_	74 75 76 77 chelo bler 51 52	148 150 152 154 ons FSC n S 10 10	2 Ech_: 2 Ech_: 2 Ech_: N design P 4 52 6 53	111 12 13 instan D 52 53	224 226 228 ces wit R 104 106	112 113 114 h num Te	224 226 228 nber o st Pro 3Ech_3 3Ech_3	2E 2E 2E f facili blem 101	ities. 204 204 206	298 300 302 P 102 103	149 150 151 D 102 103	298 300 302 R 204 206
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_3	72 36 74 37 76 38 78 39 1 5 4 6 8	72 74 76 78 Sable 2 2 3 4	2Ec 2Ec 2Ec 2Ec A: 2. Ger D 2 3 4	ch_73 ch_74 ch_75 ch_76 nerate R 4 6 8	148 150 152 154 ed three ec Test Pro 3Ech_ 3Ech_ 3Ech_	74 75 76 77 chelo bler 51 52 53	148 150 152 154 ons FSC n S 10 10 10	2Ech_: 2Ech_: 2Ech_: N design P 4 52 6 53 8 54	instan D 52 53 54	224 226 228 ces wite R 104 106 108	112 113 114 h num Te	224 226 228 nber o st Pro 3Ech_1 3Ech_1	2E 2E 2E f facili b blem 101 102 103	ch_148 ch_149 ch_150 ities. <u>\$</u> 204 206 208	298 300 302 P 102 103 104	149 150 151 D 102 103 104	298 300 302 R 204 206 208
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_3 3Ech_4	72 36 74 37 76 38 78 39 7 5 4 6 8 10	72 74 76 78 Yable 2 2 3 4 5	2 E c 2 E c	ch_73 ch_74 ch_75 ch_76 nerate R 4 6 8 10	148 150 152 154 ed three ec Test Pro 3Ech_ 3Ech_ 3Ech_ 3Ech_	74 75 76 77 chelc bler 51 52 53 53	148 150 152 154 ms FSC n S 10 10 10 10	2Ech_2 2Ech_2 2Ech_2 N design P 4 52 6 53 8 54 0 55	instan D 52 53 54 55	224 226 228 ces wite R 104 106 108 110	112 113 114 th num Te	224 226 228 nber o st Pro 3Ech_1 3Ech_1 3Ech_1	2E 2E 2E f facili blem 101 102 103 104	ch_148 ch_149 ch_150 ities. <u>\$</u> 204 206 208 210	298 300 302 P 102 103 104 105	149 150 151 D 102 103 104 105	298 300 302 R 204 206 208 210
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_3 3Ech_3 3Ech_4 3Ech_5	72 36 74 37 76 38 78 39 1 S 4 6 8 10 12	72 74 76 78 Table 2 2 3 4 5 6	2 E c 2 E c 2 E c 2 E c 2 E c 2 E c 2 E c 4: 2. Ger 2 3 4 5 6	ch_73 ch_74 ch_75 ch_76 merate R 4 6 8 10 12	148 150 152 154 ed three ec Test Pro 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_	74 75 76 77 chelo bler 51 52 53 54 55	148 150 152 154 ms FSC n S 100 100 110 111	2 Ech_: 2 Ech_: 2 Ech_: 2 Ech_: N design P 4 52 6 53 8 54 0 55 2 56	111 12 13 instan D 52 53 54 55 55 56	224 226 228 ces wite R 104 106 108 110 112	112 113 114 h num Te	224 226 228 nber o st Pro 3Ech_1 3Ech_1 3Ech_1 3Ech_1	2E 2E 2E f facili bblem 101 102 103 104 105	ch_148 ch_149 cch_150 ities. 204 206 208 210 212	298 300 302 P 102 103 104 105 106	149 150 151 D 102 103 104 105 106	298 300 302 R 204 206 208 210 212
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_3 3Ech_3 3Ech_4 3Ech_5 3Ech_6	72 36 74 37 76 38 78 39 7 5 4 6 8 10 12 14	72 74 76 78 'able / 2 3 4 5 6 7	2 E c 2 E c	ch_73 ch_74 ch_75 ch_76 merate R 4 6 8 10 12 14	148 150 152 154 ed three ec Test Pro 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_	74 75 76 77 chelc bler 51 52 53 54 55 55	148 150 152 154 ons FSC n S 10 10 10 11 11 11	2 Ech_: 2 E	instan D 52 53 54 55 56 57	224 226 228 ces wite R 104 106 108 110 112 114	112 113 114 h num Te	224 226 228 nber o st Pro 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3	2E 2E 2E f facili blem 101 102 103 104 105 106	ch_148 ch_149 ch_150 ities.	298 300 302 P 102 103 104 105 106 107	149 150 151 D 102 103 104 105 106 107	298 300 302 R 204 206 208 210 212 214
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_2 3Ech_3 3Ech_4 3Ech_5 3Ech_5 3Ech_6 3Ech_7	72 36 74 37 76 38 78 39 7 5 4 6 8 10 12 14 16	72 74 76 78 able 2 3 4 5 6 7 8	2 E c 2 E c	ch_73 ch_74 ch_75 ch_76 merate R 4 6 8 10 12 14 16	148 150 152 154 ed three ec Test Pro 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_	74 75 76 77 chelc bler 51 52 53 54 55 55 56 57	148 150 152 154 ons FSC n S 100 100 100 111 111 111	2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	instan D 52 53 54 55 56 57 58	224 226 228 ces wite R 104 106 108 110 112 114 116	112 113 114 h num Te	224 226 228 nber o st Pro 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3	2E 2E 2E f facili blem 101 102 103 104 105 106 107	ch_148 ch_149 ch_150 ities.	298 300 302 P 102 103 104 105 106 107 108	149 150 151 D 102 103 104 105 106 107 108	298 300 302 R 204 206 208 210 212 214 216
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_2 3Ech_3 3Ech_4 3Ech_5 3Ech_5 3Ech_6 3Ech_7 3Ech_8	72 36 74 37 76 38 78 39 7 5 4 6 8 10 12 14 16 18	72 74 76 78 Table 2 3 4 5 6 7 8 9	2 Ec 2 Ec 2 Ec 2 Ec 2 Ec 2 Ec 2 2 3 4 5 6 7 8 9	ch_73 ch_74 ch_75 ch_76 merate R 4 6 8 10 12 14 16 18	148 150 152 154 ed three ec Test Pro 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_	74 75 76 77 chelo bler 51 52 53 54 55 55 56 57 58	148 150 152 154 ons FSC n S 10 10 10 11 11 11 11 11 11 11	2Ech_2 2E	instan D 52 53 54 55 56 57 58 59	224 226 228 ces wite R 104 106 108 110 112 114 116 118	112 113 114 th num Te	224 226 228 nber o st Pro 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_	2E 2E 2E 2E 0 0 0 0 0 101 102 103 104 105 106 107 108	ch_148 ch_149 ch_150 ities. S 204 206 208 210 212 214 216 218	298 300 302 P 102 103 104 105 106 107 108 109	149 150 151 D 102 103 104 105 106 107 108 109	298 300 302 R 204 206 208 210 212 214 216 218
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_2 3Ech_3 3Ech_4 3Ech_5 3Ech_5 3Ech_6 3Ech_7 3Ech_8 3Ech_9	72 36 74 37 76 38 78 39 7 5 4 6 8 10 12 14 16 18 20	72 74 76 78 °able . 2 3 4 5 6 7 8 9 10	2 E c 2 E c	ch_73 ch_74 ch_75 ch_76 merate R 4 6 8 10 12 14 16 18 20	148 150 152 154 ed three ec 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_	74 75 76 77 chelo bler 51 52 53 54 55 55 56 57 58 59	148 150 152 154 ons FSC n S 10 10 10 11 11 11 11 11 11 11 11 11	2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 0 Est 4 52 6 53 8 54 0 55 2 56 4 57 6 58 8 59 0 60	instan 52 53 54 55 56 57 58 59 60	224 226 228 ces witt R 104 106 108 110 112 114 116 118 120	112 113 114 th num Te	224 226 228 nber o st Pro 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3	2E 2E 2E 2E 101 101 102 103 104 105 106 107 108 109	ch_148 ch_149 ch_150 ities. 204 206 208 210 212 214 216 218 220	298 300 302 P 102 103 104 105 106 107 108 109 110	149 150 151 D 102 103 104 105 106 107 108 109 110	298 300 302 R 204 206 208 210 212 214 216 218 220
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_2 3Ech_3 3Ech_4 3Ech_5 3Ech_6 3Ech_7 3Ech_8 3Ech_9 3Ech_10	72 36 74 37 76 38 78 39 7 5 4 6 8 10 12 14 16 18 20 22	72 74 76 78 Sable J 2 3 4 5 6 7 8 9 10 11	2 E c 2 E c	ch_73 ch_74 ch_75 ch_76 merate R 4 6 8 10 12 14 16 18 20 22	148 150 152 154 ed three ec 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_	74 75 76 77 chelc 51 52 53 54 55 55 55 56 57 58 59 60	148 150 152 154 ons FSC n S 100 100 110 111 111 111 112 122 122	2Ech_2 2Ech_2 2Ech_2 2Ech_2 2Ech_2 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	instan D 52 53 54 55 56 57 58 59 60 61	224 226 228 ces witt R 104 106 108 110 112 114 116 118 120 122	112 113 114 h num Te	224 226 228 nber o st Pro 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1	2E 2E 2E 2E 101 101 102 103 104 105 106 107 108 109 110	ich_148 ich_149 ich_150 ities. 204 206 208 210 212 214 216 218 220 222	298 300 302 P 102 103 104 105 106 107 108 109 110 111	149 150 151 D 102 103 104 105 106 107 108 109 110 111	298 300 302 R 204 206 208 210 212 214 216 218 220 222
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_2 3Ech_3 3Ech_4 3Ech_5 3Ech_4 3Ech_5 3Ech_6 3Ech_7 3Ech_8 3Ech_9 3Ech_10 3Ech_11	72 36 74 37 76 38 78 39 78 39 7 4 6 8 10 12 14 16 18 20 22 24	72 74 76 78 °able <i>2</i> 3 4 5 6 7 8 9 10 11 12	2 E c 2 4 5 6 7 8 9 10 11 11 12	ch_73 ch_74 ch_75 ch_76 nerate R 4 6 8 10 12 14 16 18 20 22 24	148 150 152 154 ed three ec 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_	74 75 76 77 chelc 51 52 53 54 55 55 55 55 56 57 58 59 60 61	148 150 152 154 ons FSC n S 100 100 110 111 111 111 112 12 12 12 12 12	2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 N design 7 4 52 6 53 8 54 0 55 2 56 4 57 6 58 8 59 0 60 2 61 4 62	111 12 13 instan 52 53 54 55 56 57 58 59 60 61 62	224 226 228 ces witt 104 106 108 110 112 114 116 118 120 122 124	112 113 114 h nun Te	224 226 228 nber o st Pro 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1	2E 2E 2E 2E 101 101 102 103 104 105 106 107 108 109 110 111	ich_148 ich_149 ich_150 ities. 204 206 208 210 212 214 216 218 220 222 224	298 300 302 P 102 103 104 105 106 107 108 109 110 111 112	149 150 151 D 102 103 104 105 106 107 108 109 110 111 112	298 300 302 R 204 206 208 210 212 214 216 218 220 222 224
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_2 3Ech_3 3Ech_4 3Ech_5 3Ech_5 3Ech_6 3Ech_7 3Ech_6 3Ech_7 3Ech_8 3Ech_9 3Ech_10 3Ech_11 3Ech_12	$\begin{array}{cccc} 72 & 36 \\ 74 & 37 \\ 76 & 38 \\ 78 & 39 \\ \hline & 1 \\ \hline & \\ 8 \\ 10 \\ 12 \\ 14 \\ 16 \\ 18 \\ 20 \\ 22 \\ 24 \\ 26 \\ \end{array}$	72 74 76 78 °able . 2 3 4 5 6 7 8 9 10 11 12 13	2 E c 2 E c	ch_73 ch_74 ch_75 ch_76 nerate R 4 6 8 10 12 14 16 18 20 22 24 26	148 150 152 154 ed three ec Test Pro 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_	74 75 76 77 chelc 51 52 53 54 55 55 55 56 57 58 59 60 61 62	148 150 152 154 ons FSC n S 100 100 100 110 111 111 111 112 122 122 122 122 122 12 12 12 12	2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 7 4 52 6 53 8 54 0 55 2 56 4 57 6 58 8 59 0 60 2 61 4 62 6 63	111 12 13 instan D 52 53 54 55 56 57 58 59 60 61 62 63	224 226 228 ces wit 104 106 108 110 112 114 116 118 120 122 124 126	112 113 114 h num Te	224 226 228 nber o st Pro 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_	2E 2E 2E 2E 101 101 102 103 104 105 106 107 108 109 110 111 112	ch_148 ch_149 ch_150 ities.	298 300 302 P 102 103 104 105 106 107 108 109 110 111 112 113	149 150 151 102 103 104 105 106 107 108 109 110 111 112 113	298 300 302 R 204 206 208 210 212 214 216 218 220 222 224 226
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_2 3Ech_3 3Ech_4 3Ech_5 3Ech_5 3Ech_6 3Ech_7 3Ech_6 3Ech_7 3Ech_8 3Ech_9 3Ech_10 3Ech_11 3Ech_12 3Ech_13	72 36 74 37 76 38 78 39 7 S 4 6 8 10 12 14 16 18 20 22 24 24 26 28	72 74 76 78 °able . P 2 3 4 5 6 7 8 9 10 11 12 13 14	2 E c 2 E c	ch_73 ch_74 ch_75 ch_76 nerate R 4 6 8 10 12 14 16 18 20 22 24 26 28	148 150 152 154 ed three ec 3Ech_	74 75 76 77 chelc 51 52 53 54 55 55 55 55 56 57 58 59 60 61 62 63	148 150 152 154 ons FSC n S 100 100 100 100 110 111 111 111 112 122 122 122 122 122 122 122 12	2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 7 8 9 4 5 7 6 5 8 5 4 5 7 6 5 8 5 4 5 7 6 5 8 5 9 0 6 0 6 5 8 5 9 0 6 6 5 8 5 9 0 6 6 5 8 5 4 5 7 6 5 8 5 7 6 5 8 5 7 6 5 8 5 7 6 5 8 5 7 6 5 7 6 5 7 6 5 7 6 5 7 6 5 7 6 5 7 6 5 7 6 5 7 6 5 7 6 5 7 6 5 7 6 5 7 6 5 7 6 5 7 6 5 7 6 5 8 5 7 6 5 7 6 5 7 6 5 7 6 5 7 6 5 8 5 7 6 5 8 5 7 6 5 8 5 7 6 5 8 5 7 6 5 8 5 7 6 6 6 6 6 6 8 5 8 5 9 0 6 6 6 3 8 5 7 6 6 6 6 3 8 5 7 6 6 6 6 6 3 8 5 8 5 7 6 6 6 3 8 5 7 6 6 6 3 8 5 8 5 7 6 6 6 3 8 5 8 6 6 3 8 5 8 6 6 3 8 5 8 6 6 3 8 5 8 6 6 6 8 8 6 6 3 8 6 6 6 8 8 6 7 8 6 7 8 6 7 8 6 7 8 6 7 8 8 6 7 8 6 7 8 6 7 8 6 7 8 6 7 8 6 7 8 6 7 8 6 7 8 6 7 8 6 7 8 6 7 8 6 7 8 7 8 7 7 8 7 7 7 7 7 7 7 7 7 7 7 7 7	111 12 113 instan D 52 53 54 55 56 57 58 59 60 61 62 63 64	224 226 228 ces witi R 104 106 108 110 112 114 116 118 120 122 124 126 128	112 113 114 th num Te	224 226 228 nber o st Pro 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3 3Ech_3	2E 2E 2E 2E 2E 101 101 102 103 104 105 106 107 108 109 110 111 112 113	ich_148 ich_149 ich_150 ities. 204 206 208 210 212 214 216 218 220 224 226 228	298 300 302 P 102 103 104 105 106 107 108 109 110 111 112 113 114	149 150 151 102 103 104 105 106 107 108 109 110 111 112 113 114	298 300 302 R 204 206 208 210 212 214 216 218 220 222 224 226 228
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2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_2 3Ech_3 3Ech_4 3Ech_5 3Ech_6 3Ech_5 3Ech_6 3Ech_7 3Ech_8 3Ech_9 3Ech_10 3Ech_11 3Ech_12 3Ech_13 3Ech_14 3Ech_15	$\begin{array}{cccc} 72 & 36 \\ 74 & 37 \\ 76 & 38 \\ 78 & 39 \\ \hline & 10 \\ 12 \\ 14 \\ 16 \\ 18 \\ 20 \\ 22 \\ 24 \\ 26 \\ 28 \\ 30 \\ 32 \\ \end{array}$	72 74 76 78 °able <i>J</i> P 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	2 E c 2 4 5 6 7 8 9 10 11 12 13 14 15 16	ch_73 ch_74 ch_75 ch_76 merate R 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32	148 150 152 154 ed three ec 3Ech_3Ech_	74 75 76 77 chelc 51 52 53 55 55 55 55 55 60 61 62 63 64 65	148 150 152 154 ons FSC n S 100 100 100 110 111 111 111 112 122 122 122 133 13	2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 7 6 53 8 54 0 55 2 56 4 57 6 58 8 59 0 60 2 61 4 62 6 63 8 64 0 65 2 66	instan 112 113 instan D 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66	224 226 228 ces witt 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132	112 113 114 th num Te	224 226 228 nber o st Pro 3Ech_3 3Ech	2E 2E 2E 2E 2E 101 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115	ich_148 ich_149 ich_150 ities. 204 206 208 210 212 214 216 218 220 224 226 230 232	298 300 302 P 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116	149 150 151 D 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116	298 300 302 R 204 206 208 210 212 214 216 218 220 222 224 226 228 230 232
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_3 3Ech_4 3Ech_5 3Ech_6 3Ech_5 3Ech_6 3Ech_7 3Ech_8 3Ech_7 3Ech_8 3Ech_9 3Ech_10 3Ech_11 3Ech_12 3Ech_13 3Ech_14 3Ech_15 3Ech_16	$\begin{array}{cccc} 72 & 36 \\ 74 & 37 \\ 76 & 38 \\ 78 & 39 \\ \hline & & & \\ 78 & 39 \\ \hline & & & \\ 78 & 39 \\ \hline & & & \\ 78 & 39 \\ \hline & & & \\ 8 \\ 10 \\ 12 \\ 14 \\ 6 \\ 18 \\ 20 \\ 22 \\ 24 \\ 26 \\ 28 \\ 30 \\ 32 \\ 34 \\ \end{array}$	72 74 76 78 °able <i>J</i> 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17	2 E c 2 4 5 6 7 8 9 10 11 12 13 14 15 16 17	ch_73 ch_74 ch_75 ch_76 merate R 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34	148 150 152 154 ed three ec 3Ech_3Ech_ 3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_ 3Ech_3Ech_ 3E	74 75 76 77 51 52 53 55 55 55 55 55 55 55 60 61 62 63 64 65 66	148 150 152 154 ons FSC n S 100 100 100 110 111 111 111 112 122 122 122 133 133	2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 6 53 8 54 0 55 2 56 4 57 6 58 8 59 0 60 2 61 4 62 6 63 8 64 0 65 2 66 4 67	instan 112 113 instan D 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67	224 226 228 ces witt 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134	112 113 114 h num Te	224 226 228 nber o st Pro 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1 3Ech_1	2E 2E 2E 2E 2E 2E 2E 2E 101 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116	ich_148 ich_149 ich_150 ities. 204 206 208 210 212 214 216 218 220 224 226 232 234	298 300 302 P 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117	149 150 151 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117	298 300 302 204 206 208 210 212 214 216 218 220 222 224 226 228 230 232 234
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_2 3Ech_3 3Ech_4 3Ech_5 3Ech_6 3Ech_5 3Ech_6 3Ech_7 3Ech_8 3Ech_9 3Ech_10 3Ech_11 3Ech_12 3Ech_13 3Ech_14 3Ech_15 3Ech_16 3Ech_17	72 36 74 37 76 38 78 39 7 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36	72 74 76 78 °able . P 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	2Ec 2Ec 2Ec 2Ec 2Ec 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	ch_73 ch_74 ch_75 ch_76 merate R 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36	148 150 152 154 ed three ec 3Ech_3Ech_ 3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_ 3Ech_3Ech_ 3E	$\begin{array}{c} 74 \\ 75 \\ 76 \\ 77 \\ \hline \\ 51 \\ 52 \\ 53 \\ 55 \\ 55 \\ 55 \\ 55 \\ 55 \\ 55$	148 150 152 154 ons FSC n S 100 100 100 110 111 111 111 112 122 122 122 123 133 133 133 133	2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 6 53 8 54 0 55 2 56 4 57 6 58 8 59 0 60 2 61 4 62 6 63 8 64 0 65 2 66 4 67 6 68	111 12 13 instan 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68	224 226 228 ces witt 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136	112 113 114 h nun Te	224 226 228 nber o st Pro 3Ech_	2E 2E 2E 2E 2E 2E 2E 2E 2E 101 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117	ich_148 ich_149 ich_150 ities. 204 206 208 210 212 214 216 218 220 224 226 230 232 234 236	298 300 302 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118	149 150 151 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118	298 300 302 204 206 208 210 212 214 216 218 220 222 224 226 228 230 232 234 236
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_3 3Ech_4 3Ech_5 3Ech_5 3Ech_6 3Ech_7 3Ech_6 3Ech_7 3Ech_8 3Ech_9 3Ech_10 3Ech_11 3Ech_12 3Ech_13 3Ech_14 3Ech_15 3Ech_16 3Ech_17 3Ech_18	72 36 74 37 76 38 78 39 78 39 7 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38	72 74 76 78 °able. 9 10 11 12 13 14 15 16 17 18 19	2EC 2EC 2EC 2EC 2EC 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	ch_73 ch_74 ch_75 ch_76 nerate R 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38	148 150 152 154 ed three ec 3Ech_3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_ 3Ech_3Ech_ 3Ech_ 3Ech_3Ech_ 3E	$\begin{array}{c} 74 \\ 75 \\ 76 \\ 77 \\ \hline \\ 51 \\ 52 \\ 53 \\ 55 \\ 55 \\ 55 \\ 55 \\ 55 \\ 60 \\ 61 \\ 62 \\ 63 \\ 66 \\ 66 \\ 66 \\ 66 \\ 66 \\ 68 \\ \end{array}$	148 150 152 154 ons FSC n S 100 100 100 110 111 111 111 112 122 122 123 133 133 133 133 133	2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 6 53 8 54 0 55 2 56 4 57 6 58 8 59 0 60 2 61 4 62 6 63 8 64 0 65 2 66 4 67 6 68 8 69	111 12 13 instan 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69	224 226 228 ces witt 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138	112 113 114 h num Te	224 226 228 nber o st Pro 3Ech_	2E 2E 2E 2E 2E 2E 2E 2E 101 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118	ich_148 ich_149 ich_150 ities. 204 206 208 210 212 214 216 218 220 224 226 230 232 234 236 238	298 300 302 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119	149 150 151 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119	298 300 302 204 206 208 210 212 214 216 218 220 222 224 226 228 230 232 234 236 238
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_3 3Ech_4 3Ech_5 3Ech_6 3Ech_7 3Ech_6 3Ech_7 3Ech_8 3Ech_9 3Ech_10 3Ech_11 3Ech_12 3Ech_13 3Ech_14 3Ech_15 3Ech_14 3Ech_17 3Ech_18 3Ech_19	72 36 74 37 76 38 78 39 78 39 7 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40	72 74 76 78 °able 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	2 E c 2 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 20 2	ch_73 ch_74 ch_75 ch_76 merate R 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40	148 150 152 154 ed three ec 3Ech_	$\begin{array}{c} 74 \\ 75 \\ 76 \\ 77 \\ \hline \\ \textbf{bler} \\ 51 \\ 52 \\ 53 \\ 55 \\ 55 \\ 55 \\ 55 \\ 55 \\ 55$	148 150 152 154 ons FSC n S 100 100 100 100 100 100 100 101 111 111 111 112 122 122 122 123 133 133 133 134	2 Ech_ 2 Ech_	11 12 13 instan D 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70	224 226 228 ces witt R 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138 140	112 113 114 h num Te	224 226 228 nber o st Pro 3Ech_	2E 2E 2E 2E 2E 2E 101 102 103 104 105 106 107 108 107 108 109 110 111 112 113 114 115 116 117 118 117 118 119	ich_148 ich_149 ich_150 ities. 204 206 208 210 212 214 216 218 220 224 226 234 236 238 240	298 300 302 P 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120	149 150 151 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120	298 300 302 204 206 208 210 212 214 216 218 220 222 224 226 222 224 226 228 230 232 234 236 238 240
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_2 3Ech_3 3Ech_4 3Ech_5 3Ech_5 3Ech_6 3Ech_7 3Ech_6 3Ech_7 3Ech_8 3Ech_7 3Ech_10 3Ech_11 3Ech_12 3Ech_13 3Ech_14 3Ech_15 3Ech_14 3Ech_15 3Ech_16 3Ech_17 3Ech_18 3Ech_19 3Ech_20	72 36 74 37 76 38 78 39 78 39 7 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42	72 74 76 78 °able 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21	2 E c 2 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 2 2 2 2 2 2 2 2 2 2 2 2 2	ch_73 ch_74 ch_75 ch_76 merate R 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42	148 150 152 154 ed three ec 3Ech_	74 75 76 77 chelc bler 51 52 53 55 55 55 55 55 55 61 62 63 66 66 66 66 66 67 66 67 66 67 66 67 66 67 66 67 66 67 77 7	148 150 152 154 ons FSC n S 100 100 100 101 111 111 111 112 122 122 123 133 133 133 144 14	2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 2 Ech_2 6 53 8 54 0 55 2 56 4 57 6 58 8 59 0 60 2 61 4 62 6 63 8 64 0 65 2 66 4 67 6 68 8 69 0 70 2 71	instan 112 113 instan D 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71	224 226 228 ces witt R 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138 140 142	112 113 114 h num Te	224 226 228 nber o st Pro 3Ech_	2E 2E 2E 2E 2E 2E 2E 2E 2E 2E 2E 2E 2E 2	ich_148 ich_149 ich_150 ities. 204 206 208 210 212 214 216 222 224 226 230 232 234 236 238 240 242	298 300 302 P 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121	149 150 151 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121	298 300 302 204 206 208 210 212 214 216 218 220 222 224 226 228 220 222 224 226 228 230 232 234 236 238 240 242
2Ech_35 2Ech_36 2Ech_37 2Ech_38 Test Problem 3Ech_1 3Ech_2 3Ech_3 3Ech_4 3Ech_5 3Ech_6 3Ech_7 3Ech_6 3Ech_7 3Ech_8 3Ech_9 3Ech_10 3Ech_11 3Ech_12 3Ech_13 3Ech_14 3Ech_15 3Ech_14 3Ech_15 3Ech_16 3Ech_17 3Ech_18 3Ech_19 3Ech_20 3Ech_21	72 36 74 37 76 38 78 39 78 39 7 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44	72 74 76 78 °able <i>J</i> 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22	2 E c 2 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 2 2 2 2 2 2 2 2 2 2 2 2 2	ch_73 ch_74 ch_75 ch_76 merate R 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44	148 150 152 154 ed three ec 3Ech_	74 75 76 77 51 52 53 55 55 55 55 55 55 61 62 63 64 65 66 66 67 68 69 77 71 71 72 72 73 74 75 76 76 76 76 77	148 150 152 154 ons FSC n S 100 100 100 101 111 111 111 112 122 122 123 133 133 133 144 14 14	2 Ech_ 2 Ech_	instan 112 113 instan D 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72	224 226 228 ces witt R 104 106 108 110 112 114 116 118 120 122 124 126 128 130 122 124 126 128 130 132 134 136 138 140 142 144	112 113 114 h num Te	224 226 228 nber o st Pro 3Ech_	2E 2E 2E 2E 2E 2E 2E 2E 2E 2E 2E 2E 2E 2	ich_148 ich_149 ich_150 ities. 204 206 208 210 212 214 216 218 220 224 226 230 232 234 236 238 240 242 244	298 300 302 P 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122	149 150 151 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122	298 300 302 204 206 208 210 212 214 216 218 220 222 224 226 228 230 232 234 236 238 240 242 244

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							Table	A: 2.	Cont.								
3Ech_23	4	8	24	24	48	3Ech_73	14	48	74	74	148	3Ech_123	24	48	124	124	248
3Ech_24	5	0	25	25	50	3Ech_74	15	50	75	75	150	3Ech_124	2	50	125	125	250
3Ech_25	5	2	26	26	52	3Ech_75	15	52	76	76	152	3Ech_125	2	52	126	126	252
3Ech_26	5	4	27	27	54	3Ech_76	15	54	77	77	154	3Ech_126	2	54	127	127	254
3Ech_27	5	6	28	28	56	3Ech_77	15	56	78	78	156	3Ech_127	2	56	128	128	256
3Ech_28	5	8	29	29	58	3Ech_78	15	58	79	79	158	3Ech_128	2	58 3	129	129	258
3Ech_29	6	0	30	30	60	3Ech_79	16	60	80	80	160	3Ech_129	20	60	130	130	260
3Ech_30	6	2	31	31	62	3Ech_80	16	62	81	81	162	3Ech_130	20	62	131	131	262
3Ech_31	6	64	32	32	64	3Ech_81	16	64	82	82	164	3Ech_131	20	64	132	132	264
3Ech_32	6	6	33	33	66	3Ech_82	16	66	83	83	166	3Ech_132	20	66	133	133	266
3Ech_33	6	8	34	34	68	3Ech_83	16	68	84	84	168	3Ech_133	20	68	134	134	268
3Ech_34	7	0	35	35	70	3Ech_84	17	70	85	85	170	3Ech_134	27	70	135	135	270
3Ech_35	7	2	36	36	72	3Ech_85	17	72	86	86	172	3Ech_135	2	72	136	136	272
3Ech_36	7	'4	37	37	74	3Ech_86	17	74	87	87	174	3Ech_136	2	74	137	137	274
3Ech_37	7	6	38	38	76	3Ech_87	17	76	88	88	176	3Ech_137	27	76	138	138	276
3Ech_38	7	'8	39	39	78	3Ech_88	17	78	89	89	178	3Ech_138	2	78	139	139	278
3Ech_39	8	80	40	40	80	3Ech_89	18	80	90	90	180	3Ech_139	28	80 3	140	140	280
3Ech_40	8	32	41	41	82	3Ech_90	18	82	91	91	182	3Ech_140	28	82	141	141	282
3Ech_41	8	84	42	42	84	3Ech_91	18	84	92	92	184	3Ech_141	28	84 1	142	142	284
3Ech_42	8	86	43	43	86	3Ech_92	18	86	93	93	186	3Ech_142	28	86 3	143	143	286
3Ech_43	8	8	44	44	88	3Ech_93	18	88	94	94	188	3Ech_143	28	88 3	144	144	288
3Ech_44	9	0	45	45	90	3Ech_94	19	90	95	95	190	3Ech_144	29	90	145	145	290
3Ech_45	9	2	46	46	92	3Ech_95	19	92	96	96	192	3Ech_145	29	92	146	146	292
3Ech_46	9	4	47	47	94	3Ech_96	19	94	97	97	194	3Ech_146	29	94	147	147	294
3Ech_47	9	6	48	48	96	3Ech_97	19	96	98	98	196	3Ech_147	29	96	148	148	296
3Ech_48	9	8	49	49	98	3Ech_98	19	98	99	99	198	3Ech_148	29	98	149	149	298
2Eab 40	1/	0.0	F 0	F 0	100	2Eab 00	20	00	100	100	200	2E-1 140	2	0.0	1	150	200
3ECII_49	11	00	50	50	100	SECII_99	20	00	100	100	200	3ECn_149	31	00.	150	150	300
3Ech_49 3Ech_50	10	00 02	50 51	50 51	100	3Ech_99	20	02	100	100	200	3Ech_149 3Ech_150	30	00 02 1	150	150 151	300 302
3Ech_49 3Ech_50	10	00 02 Ta	50 51 able /	50 51 A: 3.	100 102 Genera	3Ech_99 3Ech_100	20 20 ns FSC	02 N de	100 101 sign ir	100 101	200 202 es with	3Ech_149 3Ech_150	30 30 ities.	00 02	150	150 151	300 302
3Ech_49 3Ech_50	10	00 02 Ta	50 51 able <i>I</i>	50 51 A: 3.	100 102 Genera	3Ech_99 3Ech_100 ated four echelor	2(ns FSC	02 N de	100 101 sign ir	100 101 nstance	200 202 es with	3Ech_149 3Ech_150 number of facil	30 30 ities.	02	150	150	300 302
3Ech_50	10 10	00 02 Ta	50 51 able <i>I</i>	50 51 A: 3. (100 102 Genera C	3Ech_99 3Ech_100 ated four echelor Test Problem	2(ns FSC S	02 N de P	100 101 sign ir	100 101 Instance	200 202 es with C	3Ecn_149 3Ech_150 number of facil Test Problem	30 30 ities.	00 . 02 2	150 151 D	150 151 R	300 302 C
3Ech_50 3Ech_50 Test Problem 4Ech 1	10 10 <u>S</u>	00 02 Ta P 2	50 51 able <i>i</i> D 2	50 51 A: 3. (R 2	100 102 Genera C	3Ech_99 3Ech_100 ated four echelor Test Problem 4Ech 51	2(ns FSC <u>S</u> 104	02 N de P 52	100 101 sign ir D 52	100 101 nstance R 52	200 202 es with C	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101	3(3(ities. S 204	00 1 02 1 P 102	150 151 D	150 151 R 102	300 302 C
3Ech_50 3Ech_50 Test Problem 4Ech_1 4Ech_2	10 10 S 4 6	00 02 Ta P 2 3	50 51 able <i>A</i> 2 3	50 51 A: 3. 0 R 2 3	100 102 Genera C	3Ech_99 3Ech_100 ated four echelor Test Problem 4Ech_51 4Ech_52	20 20 ns FSC S 104 106	$\frac{100}{100}$ N de $\frac{P}{52}$ 53	100 101 sign ir D 52 53	100 101 nstance R 52 53	200 202 es with C 104 106	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102	30 30 204 206	00 1 02 1 P 102 103	150 151 D 102 103	150 151 R 102 103	300 302 C 204 206
3Ech_50 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3	10 10 S 4 6 8	00 02 Ta P 2 3 4	50 51 able <i>A</i> D 2 3 4	50 51 A: 3. (R 2 3 4	100 102 Genera C 4 6 8	3Ech_99 3Ech_100 ated four echelor Test Problem 4Ech_51 4Ech_52 4Ech_53	20 20 ns FSC 5 104 106 108	02 N de P 52 53 54	100 101 sign ir D 52 53 54	100 101 nstance R 52 53 54	200 202 es with C 104 106 108	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Fch_103	30 30 30 30 30 30 30 204 206 208	P 102 103	D 102 103 104	R 102 103 104	300 302 C 204 206 208
3Ech_50 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_3 4Ech_4	10 10 5 4 6 8 10	00 02 Ta P 2 3 4 5	50 51 able <i>A</i> 2 3 4 5	50 51 A: 3. 0 R 2 3 4 5	100 102 Genera C 4 6 8 10	3Ech_99 3Ech_100 ated four echelor Test Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_53	20 20 ns FSC 5 104 106 108 110	02 N de P 52 53 54 55	100 101 sign ir D 52 53 54 55	100 101 nstance R 52 53 54 55	200 202 es with C 104 106 108 110	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_104	30 30 ities. S 204 206 208 210	P 102 103 104	D 102 103 104 105	R 102 103 104 105	300 302 C 204 206 208 210
3Ech_50 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_2 4Ech_3 4Ech_4 4Ech_4 4Ech_5	S 4 6 8 10 12	00 02 Ta P 2 3 4 5 6	50 51 able <i>A</i> 2 3 4 5 6	50 51 A: 3. 0 R 2 3 4 5 6	100 102 Genera C 4 6 8 10 12	3Ech_99 3Ech_100 rest Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_53 4Ech_54 4Ech_55	2(2) ns FSC <u>5</u> 104 106 108 110 112	02 N de P 52 53 54 55 55	100 101 sign ir D 52 53 54 55 56	100 101 1stance R 52 53 54 55 55 56	200 202 es with C 104 106 108 110 112	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_104 4Ech_105	30 30 ities. S 204 206 208 210 212	P 102 103 104 105	D 102 103 104 105 106	R 102 103 104 105 106	300 302 C 204 206 208 210 212
Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_4 4Ech_5 4Ech_5 4Ech_6	S 4 6 8 10 12 14	00 02 Ta P 2 3 4 5 6 7	50 51 able <i>A</i> 2 3 4 5 6 7	50 51 A: 3. (R 2 3 4 5 6 7	100 102 Genera C 4 6 8 10 12 14	3Ech_99 3Ech_100 rest Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_53 4Ech_55 4Ech_55 4Ech_55	20 20 ns FSC 104 106 108 110 112 114	02 N de P 52 53 54 55 56 57	100 101 sign ir 52 53 54 55 56 57	100 101 istance R 52 53 54 55 56 57	200 202 es with C 104 106 108 110 112 114	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_104 4Ech_105 4Ech_106	30 30 ities. 204 206 208 210 212 214	P 102 103 104 105 106 107	D 102 103 104 105 106 107	R 102 103 104 105 106 107	300 302 C 204 206 208 210 212 214
3Ech_50 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_3 4Ech_4 4Ech_5 4Ech_5 4Ech_6 4Ech_7	S S 4 6 8 10 12 14 16	00 02 7 2 3 4 5 6 7 8	50 51 able <i>A</i> 2 3 4 5 6 7 8	50 51 A: 3. 0 R 2 3 4 5 6 7 8	100 102 Genera C 4 6 8 10 12 14 16	3Ech_99 3Ech_100 ted four echelor Test Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_54 4Ech_55 4Ech_55 4Ech_56 4Ech_57	20 ns FSC 5 104 106 108 110 112 114 116	02 N de P 52 53 54 55 56 57 58	100 101 sign ir 52 53 54 55 56 57 58	100 101 nstanco R 52 53 54 55 56 57 58	200 202 es with C 104 106 108 110 112 114 116	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107	30 30 iities. 204 206 208 210 212 214 214 216	P 102 103 104 105 106 107 108	D 102 103 104 105 106 107 108	R 102 103 104 105 106 107 108	300 302 C 204 206 208 210 212 214 214
3Ech_50 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_3 4Ech_4 4Ech_5 4Ech_5 4Ech_6 4Ech_7 4Ech_8	S 4 6 8 10 12 14 16 18	00 02 Ta P 2 3 4 5 6 7 8 9	50 51 able <i>A</i> 2 3 4 5 6 7 8 9	50 51 A: 3. 0 R 2 3 4 5 6 7 8 9	100 102 Genera C 4 6 8 10 12 14 16 18	3Ech_99 3Ech_100 ated four echelor Test Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_53 4Ech_55 4Ech_55 4Ech_55 4Ech_57 4Ech_57	20 ns FSC 5 104 106 108 110 112 114 116 118	02 N de P 52 53 54 55 56 57 58 59	100 101 sign ir 52 53 54 55 56 57 58 59	100 101 nstanco R 52 53 54 55 56 57 58 59	200 202 es with C 104 106 108 110 112 114 116 118	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107 4Ech_108	30 30 iities. 204 206 208 210 212 214 216 218	P 102 103 104 105 106 107 108 109	D 102 103 104 105 106 107 108 109	R 102 103 104 105 106 107 108 109	300 302 204 206 208 210 212 214 216 218
3Ech_50 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_3 4Ech_4 4Ech_5 4Ech_6 4Ech_7 4Ech_8 4Ech_8 4Ech_9	S 4 6 8 10 12 14 16 18 20	00 02 Tra P 2 3 4 5 6 7 8 9	50 51 able 2 2 3 4 5 6 7 8 9 10	50 51 A: 3. 0 R 2 3 4 5 6 7 8 9 10	100 102 Genera C 4 6 8 10 12 14 16 18 20	3Ech_99 3Ech_100 ated four echelor Test Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_53 4Ech_55 4Ech_55 4Ech_55 4Ech_56 4Ech_57 4Ech_58 4Ech_58 4Ech_59	20 20 ns FSC 3 104 106 108 110 112 114 116 118 120	00 02 N de P 52 53 54 55 56 57 58 59 60	100 101 sign ir 52 53 54 55 56 57 58 59 60	100 101 Instance R 52 53 54 55 56 57 58 59 60	200 202 es with C 104 106 108 110 112 114 116 118 120	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107 4Ech_108 4Ech_109	30 30 30 30 30 30 30 30 30 30 30 30 30 3	P 102 103 104 105 106 107 108 109 110	D 102 103 104 105 106 107 108 109 110	R 102 103 104 105 106 107 108 109 110	300 302 C 204 206 208 210 212 214 216 218 220
3Ech_49 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_4 4Ech_4 4Ech_5 4Ech_6 4Ech_7 4Ech_8 4Ech_9 4Ech_9 4Ech_10	S 4 6 8 10 12 14 16 18 20 22	00 02 Ta P 2 3 4 5 6 7 8 9 10	D D 2 3 4 5 6 7 8 9 10 11	S0 50 51 A: 3.1 R 2 3 4 5 6 7 8 9 10 11	100 102 Genera C 4 6 8 10 12 14 16 18 20 22	3Ech_99 3Ech_100 ated four echelor Test Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_54 4Ech_55 4Ech_55 4Ech_56 4Ech_57 4Ech_58 4Ech_59 4Ech_59 4Ech_60	20 20 ns FSC 5 104 106 108 110 112 114 116 118 120 122	00 02 N de P 52 53 54 55 56 57 58 59 60 61	100 101 sign ir 52 53 54 55 56 57 58 59 60 61	100 101 101 101 101 101 101 101	200 202 es with C 104 106 108 110 112 114 116 118 120 122	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107 4Ech_108 4Ech_109 4Ech_110	30 30 itties. 204 206 208 210 212 214 216 218 220 222	P 102 103 104 105 106 107 108 109 110	D 102 103 104 105 106 107 108 109 110 111	R 102 103 104 105 106 107 108 109 110 111	300 302 204 206 208 210 212 214 216 218 220 222
SECIL49 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_5 4Ech_6 4Ech_7 4Ech_9 4Ech_10 4Ech_11	S 4 6 8 10 12 14 16 18 20 22 24	000 02 Ta 2 3 4 5 6 7 8 9 10 11 12	D 2 3 4 5 6 7 8 9 10 11 12	S0 50 51 1 A: 3.1 2 3 4 5 6 7 8 9 10 11 12	100 102 Genera C 4 6 8 10 12 14 16 18 20 22 24	3Ech_99 3Ech_100 rest Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_53 4Ech_55 4Ech_55 4Ech_55 4Ech_57 4Ech_58 4Ech_59 4Ech_59 4Ech_60 4Ech_61	2(2(ns FSC 104 106 108 110 112 114 116 118 120 122 124	N de P 52 53 54 55 56 57 58 59 60 61 62	100 101 sign ir 52 53 54 55 56 57 58 59 60 61 62	100 101 1stanco R 52 53 54 55 56 57 58 59 60 61 62	200 202 es with C 104 106 108 110 112 114 116 118 120 122 124	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107 4Ech_108 4Ech_109 4Ech_110 4Ech_111	30 30 30 30 30 30 204 206 208 210 212 214 216 218 220 222 224	P 102 103 104 105 106 107 108 109 110 111	D 102 103 104 105 106 107 108 109 110 111	R 102 103 104 105 106 107 108 109 110 111 112	300 302 204 206 208 210 212 214 216 218 220 222 224
SECIL49 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_4 4Ech_5 4Ech_6 4Ech_7 4Ech_8 4Ech_10 4Ech_11 4Ech_13	S 4 6 8 10 12 14 16 18 20 22 24 26	000 02 Tr 2 3 4 5 6 7 8 9 10 11 12 13	50 51 able <i>2</i> 3 4 5 6 7 8 9 10 11 12 13	S0 50 51 51 R 2 3 4 5 6 7 8 9 10 11 12 13 13	100 102 Genera C 4 6 8 10 12 14 16 18 20 22 24 26	3Ech_99 3Ech_100 ted four echelor Test Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_54 4Ech_55 4Ech_55 4Ech_56 4Ech_57 4Ech_58 4Ech_59 4Ech_60 4Ech_61 4Ech_61 4Ech_62	2(2(ns FSC 104 106 108 110 112 114 116 118 120 122 124 126	N de P 52 53 54 55 56 57 58 59 60 61 62 63	100 101 sign ir 52 53 54 55 56 57 58 59 60 61 62 63	100 101 1stanco R 52 53 54 55 56 57 58 59 60 61 62 63	200 202 es with C 104 106 108 110 112 114 116 118 120 122 124 126	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107 4Ech_108 4Ech_109 4Ech_110 4Ech_111 4Ech_111	30 30 30 30 30 30 204 206 208 210 212 214 216 218 220 222 224 226	P 102 103 104 105 106 107 108 109 110 111 112 113	D 102 103 104 105 106 107 108 109 110 111 112 113	R 102 103 104 105 106 107 108 109 110 111 112 113	300 302 204 206 208 210 212 214 216 218 220 222 224 226
SECIL49 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_5 4Ech_6 4Ech_7 4Ech_8 4Ech_10 4Ech_11 4Ech_13	S 4 6 8 10 12 14 16 18 20 22 24 26 28	000 02 Tr 2 3 4 5 6 7 8 9 10 11 12 13 14	S0 S0 51 51 able <i>i i</i> 2 3 4 5 6 7 8 9 10 11 12 13 14 14	S0 50 51 51 R 2 3 4 5 6 7 8 9 10 11 12 13 14	100 102 Genera C 4 6 8 10 12 14 16 18 20 22 24 26 28	3Ech_99 3Ech_100 ated four echelor Test Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_53 4Ech_55 4Ech_55 4Ech_56 4Ech_57 4Ech_58 4Ech_59 4Ech_61 4Ech_62 4Ech_62 4Ech_63	2(2(ns FSC 104 106 108 110 112 114 116 118 120 122 124 126 128	00 02 N de P 52 53 54 55 56 57 58 59 60 61 62 63 64	100 101 sign ir 52 53 54 55 56 57 58 59 60 61 62 63 64	100 101 101 101 101 101 101 101	200 202 es with C 104 106 108 110 112 114 116 118 120 122 124 126 128	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107 4Ech_108 4Ech_109 4Ech_110 4Ech_111 4Ech_112 4Ech_113	30 30 30 30 30 30 204 206 208 210 212 214 216 218 220 222 224 226 228	P 102 103 104 105 106 107 108 109 110 111 112 113 114	D 102 103 104 105 106 107 108 109 110 111 112 113 114	R 102 103 104 105 106 107 108 109 110 111 112 113 114	300 302 204 206 208 210 212 214 216 218 220 222 224 226 228
SECIL49 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_4 4Ech_5 4Ech_6 4Ech_7 4Ech_9 4Ech_10 4Ech_11 4Ech_13	s 4 6 8 10 12 14 16 18 20 22 24 26 28 30	000 02 Tr 2 3 4 5 6 7 8 9 10 11 12 13 14 15	S0 S0 51 51 able <i>i i</i> 2 3 4 5 6 7 8 9 10 11 12 13 14 15	S0 50 51 R 2 R 2 3 4 5 6 7 8 9 10 111 122 133 14 15 16 16 16 16 16 16 16 16 16 16 16 16 16 16 <th17< th=""> <th17< th=""> <th17< th=""> <</th17<></th17<></th17<>	100 102 Genera C 4 6 8 10 12 14 16 18 20 22 24 26 28 30	3Ech_100 ated four echelor Test Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_53 4Ech_55 4Ech_55 4Ech_55 4Ech_57 4Ech_58 4Ech_59 4Ech_60 4Ech_61 4Ech_62 4Ech_63 4Ech_63 4Ech_64	20 20 20 20 20 20 20 20 20 20	N de P 52 53 54 55 56 57 58 59 60 61 62 63 64 65	100 101 sign ir 52 53 54 55 56 57 58 59 60 61 62 63 64 65	100 101 Instance R 52 53 54 55 56 57 58 59 60 61 62 63 64 65	200 202 es with C 104 106 108 110 112 114 116 118 120 122 124 126 128 130	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107 4Ech_108 4Ech_109 4Ech_110 4Ech_111 4Ech_112 4Ech_113 4Ech_114	30 30 30 30 30 30 30 204 206 208 210 212 214 216 218 220 222 224 226 228 230	P 102 103 104 105 106 107 108 109 110 111 112 113 114	D 102 103 104 105 106 107 108 109 110 111 112 113 114	R 102 103 104 105 106 107 108 109 110 111 112 113 114 115	300 302 204 206 208 210 212 214 216 218 220 222 224 226 228 230
SECIL49 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_4 4Ech_5 4Ech_6 4Ech_7 4Ech_9 4Ech_11 4Ech_13 4Ech_14	S 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32	000 02 Tr 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	S0 S0 51 51 D 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	S0 50 51 1 R 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	100 102 Genera C 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32	3Ech_100 ated four echelor Test Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_53 4Ech_55 4Ech_55 4Ech_55 4Ech_57 4Ech_58 4Ech_59 4Ech_59 4Ech_61 4Ech_61 4Ech_62 4Ech_63 4Ech_64 4Ech_64 4Ech_65	20 20 20 20 20 20 20 20 20 20	N de P 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66	100 101 sign ir 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66	100 101 Instance R 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66	200 202 es with C 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107 4Ech_108 4Ech_109 4Ech_110 4Ech_111 4Ech_111 4Ech_112 4Ech_113 4Ech_114	30 30 30 30 30 30 30 30 30 30 30 30 30 3	P 1022 1033 1044 1055 1066 1077 1088 1099 1100 1111 1122 1133 1144 1155 1166	D 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116	R 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116	300 302 204 206 208 210 212 214 216 218 220 222 224 226 228 230 232
SECIL49 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_4 4Ech_5 4Ech_6 4Ech_7 4Ech_10 4Ech_11 4Ech_12 4Ech_13 4Ech_14	S 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34	D0 02 Transmission P 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17	S0 S0 51 51 D 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 17	S0 50 51 51 A: 3.4 6 7 8 9 10 11 12 13 14 15 16 17 17	100 102 Genera C 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34	3Ech_100 ated four echelor Test Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_54 4Ech_55 4Ech_56 4Ech_57 4Ech_58 4Ech_59 4Ech_60 4Ech_61 4Ech_62 4Ech_63 4Ech_64 4Ech_65 4Ech_65	2(2(ns FSC 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134	N de P 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67	100 101 sign ir 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67	100 101 101 101 101 101 101 101	200 202 es with C 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107 4Ech_108 4Ech_109 4Ech_110 4Ech_111 4Ech_111 4Ech_113 4Ech_115 4Ech_116	30 30 30 30 30 30 30 30 30 30 30 30 30 3	P 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117	D 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117	R 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117	300 302 204 206 208 210 212 214 216 218 220 222 224 226 228 230 232 234
3Ech_49 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_5 4Ech_6 4Ech_7 4Ech_8 4Ech_10 4Ech_11 4Ech_12 4Ech_15 4Ech_16	s 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36	D0 D2 Transmission P 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	S0 S0 51 3 able z 3 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	R 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	100 102 Genera C 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36	3Ech_99 3Ech_100 ated four echelor Test Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_54 4Ech_55 4Ech_55 4Ech_57 4Ech_58 4Ech_59 4Ech_61 4Ech_62 4Ech_63 4Ech_63 4Ech_65 4Ech_65 4Ech_66 4Ech_65 4Ech_66	2(2(ns FSC 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136	P F 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68	100 101 sign ir 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68	R 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68	200 202 es with C 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107 4Ech_108 4Ech_109 4Ech_110 4Ech_111 4Ech_112 4Ech_113 4Ech_114 4Ech_115 4Ech_116 4Ech_117	s ities. 204 206 208 210 212 214 216 218 220 222 224 226 228 230 232 234 236	P 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118	D 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118	R 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118	300 302 302 302 204 206 208 210 212 214 216 218 220 222 224 226 228 230 232 234 236 236
SECIL49 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_5 4Ech_6 4Ech_7 4Ech_8 4Ech_10 4Ech_11 4Ech_12 4Ech_13 4Ech_14 4Ech_15 4Ech_14	S 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38	P 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 19	S0 S0 51 51 able z Z 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 19	R 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 19	100 102 Genera C 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38	3Ech_100 ated four echelor Test Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_53 4Ech_55 4Ech_55 4Ech_56 4Ech_57 4Ech_58 4Ech_59 4Ech_61 4Ech_61 4Ech_63 4Ech_63 4Ech_65 4Ech_65 4Ech_67 4Ech_67 4Ech_67 4Ech_68	2(2(ns FSC 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138	00 02 N de P 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69	100 101 sign ir 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69	R 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69	200 202 es with C 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107 4Ech_108 4Ech_109 4Ech_110 4Ech_111 4Ech_111 4Ech_113 4Ech_114 4Ech_115 4Ech_116 4Ech_117 4Ech_118	30 30 30 30 30 30 30 30 30 30 30 30 30 20 31 20 212 214 216 218 220 222 224 226 228 230 232 234 236 238	P 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118	D 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118	R 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119	300 302 204 206 208 210 212 214 216 218 220 222 224 226 228 230 232 234 236 238
3Ech_49 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_5 4Ech_6 4Ech_7 4Ech_8 4Ech_10 4Ech_11 4Ech_12 4Ech_13 4Ech_14 4Ech_11 4Ech_12 4Ech_13 4Ech_14 4Ech_15 4Ech_16 4Ech_17 4Ech_18 4Ech_18	s 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40	000 02 Tr 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	S0 S0 51 51 abble z Z 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	S0 50 51 R 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	100 102 Genera 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40	SECI_99 3Ech_100 ated four echelor Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_54 4Ech_55 4Ech_56 4Ech_57 4Ech_58 4Ech_59 4Ech_61 4Ech_62 4Ech_63 4Ech_64 4Ech_65 4Ech_64 4Ech_65 4Ech_66 4Ech_67 4Ech_68 4Ech_68	2(2(ns FSC 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138 140	D2 D2 N de 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70	100 101 sign ir 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70	R 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70	200 202 es with C 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138 140	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107 4Ech_108 4Ech_109 4Ech_110 4Ech_110 4Ech_111 4Ech_112 4Ech_113 4Ech_114 4Ech_115 4Ech_116 4Ech_117 4Ech_118 4Ech_119	s ities. 204 206 208 210 212 214 216 218 220 222 224 226 228 230 232 234 236 238 240	P 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120	D 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120	R 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120	300 302 302 302 204 206 208 210 212 214 216 218 220 224 226 228 230 232 234 236 238 240
3Ech_49 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_4 4Ech_5 4Ech_6 4Ech_7 4Ech_9 4Ech_11 4Ech_12 4Ech_13 4Ech_14 4Ech_13 4Ech_14 4Ech_15 4Ech_14 4Ech_15 4Ech_16 4Ech_17 4Ech_18 4Ech_19 4Ech_19 4Ech_19	S 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42	000 02 Tr 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21	S0 S0 51 51 able z Z 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 21	S0 50 51 R 2 A: 3.4 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21	100 102 Genera C 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42	SECI_99 3Ech_100 ated four echelor Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_54 4Ech_55 4Ech_56 4Ech_57 4Ech_58 4Ech_59 4Ech_61 4Ech_62 4Ech_63 4Ech_64 4Ech_65 4Ech_64 4Ech_65 4Ech_64 4Ech_65 4Ech_64 4Ech_65 4Ech_67 4Ech_68 4Ech_69 4Ech_69	2(2(ns FSC 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138 140 142	P 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71	100 101 sign ir 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71	R 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71	200 202 es with C 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138 140 142	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107 4Ech_108 4Ech_109 4Ech_110 4Ech_111 4Ech_111 4Ech_111 4Ech_115 4Ech_114 4Ech_115 4Ech_116 4Ech_117 4Ech_118 4Ech_119 4Ech_120	30 30 30 30 30 30 30 204 206 208 210 212 214 216 218 220 222 224 226 222 224 226 228 230 232 234 236 238 240 242	P 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121	D 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121	R 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121	Solution 302 302 302 204 206 208 210 212 214 216 218 220 224 226 234 230 232 234 236 238 240 242
3Ech_49 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_4 4Ech_5 4Ech_6 4Ech_7 4Ech_10 4Ech_11 4Ech_12 4Ech_13 4Ech_14 4Ech_17 4Ech_18 4Ech_19 4Ech_17 4Ech_18 4Ech_19 4Ech_20 4Ech_20	S 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44	D0 D2 Train P 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22	S0 S0 51 51 D 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22	S0 50 51 51 A: 3. (1) 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22	100 102 Genera C 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44	SECI_99 3Ech_100 ated four echelor Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_54 4Ech_55 4Ech_56 4Ech_57 4Ech_58 4Ech_59 4Ech_61 4Ech_62 4Ech_63 4Ech_64 4Ech_65 4Ech_64 4Ech_65 4Ech_67 4Ech_70 4Ech_70 4Ech_70	2(2(ns FSC 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138 140 142 144	P 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72	100 101 sign ir 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72	R 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72	200 202 es with C 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138 140 142 144	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107 4Ech_108 4Ech_109 4Ech_110 4Ech_110 4Ech_111 4Ech_111 4Ech_112 4Ech_113 4Ech_114 4Ech_115 4Ech_116 4Ech_117 4Ech_118 4Ech_119 4Ech_120 4Ech_121	s ities. 204 206 208 210 212 214 216 218 220 222 224 226 228 230 232 234 236 232 234 236 238 240 242 244	P 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122	D 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122	R 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121	300 302 204 206 208 210 212 214 216 218 220 222 224 226 228 230 232 234 236 238 230 232 234 236 238 240 242 244
3Ech_49 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_4 4Ech_5 4Ech_6 4Ech_7 4Ech_10 4Ech_11 4Ech_12 4Ech_13 4Ech_14 4Ech_17 4Ech_18 4Ech_19 4Ech_17 4Ech_18 4Ech_19 4Ech_20 4Ech_21 4Ech_21	I 11 11 11 11 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44	P 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 3	S0 S0 51 51 abble 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23	S0 50 51 51 A: 3.4 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23	100 102 Genera C 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46	SECI_99 3Ech_100 ated four echelor Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_54 4Ech_55 4Ech_56 4Ech_57 4Ech_58 4Ech_60 4Ech_61 4Ech_62 4Ech_63 4Ech_64 4Ech_65 4Ech_64 4Ech_67 4Ech_67 4Ech_67 4Ech_67 4Ech_67 4Ech_67 4Ech_67 4Ech_67 4Ech_67 4Ech_70 4Ech_71 4Ech_71	2(2(ns FSC 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138 140 142 144 146	D2 D2 N de P 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73	100 101 sign ir 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73	R 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73	200 202 es with C 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138 140 142 144 146	3Ecn_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107 4Ech_108 4Ech_109 4Ech_110 4Ech_110 4Ech_111 4Ech_112 4Ech_113 4Ech_114 4Ech_115 4Ech_116 4Ech_117 4Ech_118 4Ech_119 4Ech_120 4Ech_121 4Ech_121	30 30 30 30 30 30 30 30 30 30 30 30 30 3	P 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123	D 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123	R 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123	300 302 204 206 208 210 212 214 216 218 220 222 224 226 228 230 232 234 236 238 230 232 234 236 238 240 242 244 246
SECIL49 3Ech_50 Test Problem 4Ech_1 4Ech_2 4Ech_3 4Ech_5 4Ech_6 4Ech_7 4Ech_8 4Ech_10 4Ech_11 4Ech_12 4Ech_13 4Ech_14 4Ech_15 4Ech_14 4Ech_15 4Ech_16 4Ech_17 4Ech_18 4Ech_19 4Ech_20 4Ech_21 4Ech_21 4Ech_22 4Ech_23	S 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48	P 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	S0 S0 51 51 able z Z 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	R 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24	100 102 Genera 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48	3Ech_100 ated four echelor Test Problem 4Ech_51 4Ech_52 4Ech_53 4Ech_54 4Ech_55 4Ech_56 4Ech_57 4Ech_59 4Ech_61 4Ech_62 4Ech_63 4Ech_64 4Ech_65 4Ech_66 4Ech_67 4Ech_68 4Ech_67 4Ech_67 4Ech_67 4Ech_67 4Ech_67 4Ech_67 4Ech_67 4Ech_67 4Ech_70 4Ech_71 4Ech_72 4Ech_72	2(2(ns FSC 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138 140 142 144 146 148	D2 D2 N de P 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74	100 101 sign ir 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74	R 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74	200 202 es with C 104 106 108 110 112 114 116 118 120 122 124 126 128 130 132 134 136 138 140 142 144 146 148	3Ech_149 3Ech_150 number of facil Test Problem 4Ech_101 4Ech_102 4Ech_103 4Ech_104 4Ech_105 4Ech_106 4Ech_107 4Ech_108 4Ech_109 4Ech_110 4Ech_110 4Ech_111 4Ech_112 4Ech_113 4Ech_114 4Ech_115 4Ech_115 4Ech_116 4Ech_117 4Ech_118 4Ech_119 4Ech_120 4Ech_121 4Ech_123	s ities. 204 206 208 210 212 214 216 218 220 222 224 226 228 230 232 234 236 238 240 242 244 246 248	P 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124	D 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124	R 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124	Solo 302 302 204 206 208 210 212 214 216 218 220 224 226 228 230 232 234 236 238 240 242 244 246 248

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4Ech_24	50	25	25	25	50	4Ech_74	150	75	75	75	150	4Ech_124	250	125	125	125	250
4Ech_25	52	26	26	26	52	4Ech_75	152	76	76	76	152	4Ech_125	252	126	126	126	252
4Ech_26	54	27	27	27	54	4Ech_76	154	77	77	77	154	4Ech_126	254	127	127	127	254
4Ech_27	56	28	28	28	56	4Ech_77	156	78	78	78	156	4Ech_127	256	128	128	128	256
4Ech_28	58	29	29	29	58	4Ech_78	158	79	79	79	158	4Ech_128	258	129	129	129	258
4Ech_29	60	30	30	30	60	4Ech_79	160	80	80	80	160	4Ech_129	260	130	130	130	260
4Ech_30	62	31	31	31	62	4Ech_80	162	81	81	81	162	4Ech_130	262	131	131	131	262
4Ech_31	64	32	32	32	64	4Ech_81	164	82	82	82	164	4Ech_131	264	132	132	132	264
4Ech_32	66	33	33	33	66	4Ech_82	166	83	83	83	166	4Ech_132	266	133	133	133	266
4Ech_33	68	34	34	34	68	4Ech_83	168	84	84	84	168	4Ech_133	268	134	134	134	268
4Ech_34	70	35	35	35	70	4Ech_84	170	85	85	85	170	4Ech_134	270	135	135	135	270
4Ech_35	72	36	36	36	72	4Ech_85	172	86	86	86	172	4Ech_135	272	136	136	136	272
4Ech_36	74	37	37	37	74	4Ech_86	174	87	87	87	174	4Ech_136	274	137	137	137	274
4Ech_37	76	38	38	38	76	4Ech_87	176	88	88	88	176	4Ech_137	276	138	138	138	276
4Ech_38	78	39	39	39	78	4Ech_88	178	89	89	89	178	4Ech_138	278	139	139	139	278
4Ech_39	80	40	40	40	80	4Ech_89	180	90	90	90	180	4Ech_139	280	140	140	140	280
4Ech_40	82	41	41	41	82	4Ech_90	182	91	91	91	182	4Ech_140	282	141	141	141	282
4Ech_41	84	42	42	42	84	4Ech_91	184	92	92	92	184	4Ech_141	284	142	142	142	284
4Ech_42	86	43	43	43	86	4Ech_92	186	93	93	93	186	4Ech_142	286	143	143	143	286
4Ech_43	88	44	44	44	88	4Ech_93	188	94	94	94	188	4Ech_143	288	144	144	144	288
4Ech_44	90	45	45	45	90	4Ech_94	190	95	95	95	190	4Ech_144	290	145	145	145	290
4Ech_45	92	46	46	46	92	4Ech_95	192	96	96	96	192	4Ech_145	292	146	146	146	292
4Ech_46	94	47	47	47	94	4Ech_96	194	97	97	97	194	4Ech_146	294	147	147	147	294
4Ech_47	96	48	48	48	96	4Ech_97	196	98	98	98	196	4Ech_147	296	148	148	148	296
4Ech_48	98	49	49	49	98	4Ech_98	198	99	99	99	198	4Ech_148	298	149	149	149	298
4Ech_49	100	50	50	50	100	4Ech_99	200	100	100	100	200	4Ech_149	300	150	150	150	300
4Ech_50	102	51	51	51	102	4Ech_100	202	101	101	101	202	4Ech_150	302	151	151	151	302