The State of Israel
Ministry of Education
Exam Type:
Bagrut for high schools
Exam Date: Summer 2016
Exam Number: 899381
English Translation (3)

מדינת ישראל
משרד החינוך
סוג הבחינה:
בגרות לבתי ספר על־יסודיים
מועד הבחינה: קיץ תשע"ו, 2016
מספר השאלון: 899381
תרגום לאנגלית (3)

Computer Science

מדעי המחשב

for the Reform for Meaningful Learning Program

על פי תכנית הרפורמה ללמידה משמעותית

Instructions for examinees

א. Duration of exam: Three hours

ב. Exam structure and breakdown of points:
This exam has three parts.
Part One –There are three questions in Part One and you must answer them according to the directions given in this part of the exam.
(10×1) + (15×1) – 25 points
Part Two – There are three questions in Part Two and you must answer two of them.
(2×25) – 50 points
Part Three – In Part Three, there are questions in four different tracks. Answer one question for the track in which you studied.
(1×25) – 25 points
Total – 100 points

ג. Material that may be used during the exam:
All material, except for a programmable computer.

ד. Special instructions:
(1) For all of the programs you are required to write in Part One, use only one programming language – Java or C#.
(2) **On the outer cover** of the answer booklet, write which **programming language** you are using – Java or C#.
(3) **On the outer cover** of the answer booklet, write the name of the **track in which you studied**, one of the four tracks:
Computer Systems and Assembly Language,
Introduction to Operations Research,
Computational Models or
Object-Oriented Programming.

Note: In the programs you write, you will not lose points for writing capital letters instead of lower-case letters or vice versa.
Write only in the answer booklet. Use separate pages for everything you want to use as draft material (outlines, calculations, etc.). Write "טיוטה" at the top of each draft page. Writing drafts on pages outside the answer booklet may lead to the disqualification of the exam!

הוראות לנבחן

א. משך הבחינה: שלוש שעות.

ב. מבנה השאלון ומפתח ההערכה:
בשאלון זה שלושה פרקים.
פרק ראשון – בפרק זה שלוש שאלות, ענה על פי ההוראות בפרק.
(10×1) + (15×1) — 25 נקודות
פרק שני – בפרק זה יש שלוש שאלות, ומהן עליך לענות על שתיים.
(2×25) — 50 נקודות
פרק שלישי – בפרק זה שאלות בארבע מסלולים שונים.
ענה על שאלה אחת במסלול שלמדת.
(1×25) — 25 נקודות
סה"כ — 100 נקודות

ג. חומר עזר מותר בשימוש:
כל חומר עזר, חוץ ממחשב הניתן לתכנות.

ד. הוראות מיוחדות:
(1) את כל התכניות שאתה נדרש לכתוב בשפת מחשב בפרק הראשון כתוב בשפה אחת בלבד — Java או C#.
(2) **רשום על הכריכה החיצונית** של המחברת באיזו **שפה** אתה כותב — Java או C# .
(3) **רשום על הכריכה החיצונית** של המחברת את שם ה**מסלול שלמדת.**
המסלול הוא אחד מארבעת המסלולים האלה:
מערכות מחשב ואסמבלי, מבוא לחקר ביצועים,
מודלים חישוביים, תכנות מונחה עצמים.
הערה: בתכניות שאתה כותב לא יורדו לך נקודות, אם תכתוב אות גדולה במקום אות קטנה או להפך.
כתוב במחברת הבחינה בלבד, בעמודים נפרדים, כל מה שברצונך לכתוב כטיוטה (ראשי פרקים, חישובים וכדומה). רשום "טיוטה" בראש כל עמוד טיוטה.
רישום טיוטות כלשהן על דפים מחוץ למחברת הבחינה עלול לגרום לפסילת הבחינה!

Good Luck!

בהצלחה!

Questions

This exam has three parts.

You must answer questions from <u>all three</u> parts, according to the instructions for each part.

Part One (25 points)

<u>Note</u>: For each question that requires input, there is no need to check the validity of the input.

<u>For those working in Java</u>: For each question that requires input, assume that he following command is written in the program:

```
Scanner input = new Scanner (System.in);
```

Answer Question 1 — <u>Required</u> (10 points)

1. Given: the class **Student**, which has two attributes: the student's name – name – which is a string, and a one-dimensional array arrTest of integers with a size of 3. A student's test score is stored in each cell of the array.

Using Java or C#, write a method in the class **Student** that will return the student's average grade over the three tests.

<u>Note</u>: There is no need to check the validity of the data in the array.

/Continued on page 3/

Answer one of the questions 2-3. (15 points)

2. Given: the class **Actor**, which has three attributes: identification number – id – which is a string; the actor's gender – gender – which is a string ("F" represents a female and "M" represents a male) and the number of films in which the actor has appeared – numFilms – which is an integer.

The interface of the class **Actor** is shown below written in Java and in C#.

Method declaration in Java	Description of the method
public Actor(String id, String gender, int numFilms)	Method constructs an actor with an identification number id and a gender gender who has appeared in numFilms films
public void addFilm()	Method adds 1 to the number of films in which the actor has appeared
public int compare(Actor other)	Method that returns: 1 — if the number of films in which the current actor has appeared is greater than the number of films in which the actor other has appeared 2 — if the number of films in which the current actor has appeared is smaller than the number of films in which the actor other has appeared 3 — if the number of films in which the current actor has appeared is equal to the number of films in which the actor other has appeared

(Note: This question continues on the next page.)

/Continued on page 4/

Method declaration in C#	Description of the method
public Actor(string id, string gender, int numFilms)	Method constructs an actor with an identification number id and a gender gender who has appeared in numFilms films
public void AddFilm()	Method adds 1 to the number of films in which the actor has appeared
public int Compare(Actor other)	Method that returns: 1 — if the number of films in which the current actor has appeared is greater than the number of films in which the actor other has appeared 2 — if the number of films in which the current actor has appeared is smaller than the number of films in which the actor other has appeared 3 — if the number of films in which the current actor has appeared is equal to the number of films in which the actor other has appeared

Assume that for each attribute, set and get methods are defined in Java and Set and Get methods are defined in C#.

א. Implement the constructor method of the class **Actor**.
In Java, the constructor method is:
public Actor(String id, String gender, int numFilms)
In C#, the constructor method is:
public Actor(string id, string gender, int numFilms)

ב. Implement the compare method in Java or the Compare method in C#.

ג. A one-dimensional array actArr that is 37 in size and of type **Actor** is defined in the main method of the class Program.
In Java or C#, write a method in the class Program that will accept an array of type **Actor** and an integer num that is greater than 0.
The method will print the number of actors in the array who have appeared in more than num films.

/Continued on page 5/

3. Given: the class **TvProgram**, which has three attributes. These attributes are the program code – code – which is an integer, the day of the week on which the program is broadcast – day – which is an integer between 1 and 7 (inclusive), and whether the program is sports-related – isSport – which is boolean and has a value of true if the program is sports-related and false if it is not.

Assume that for each attribute, get and set methods are defined in Java and Get and Set methods are defined in C#.

א. Using Java or C#, write a constructor method in the class **TvProgram** that will accept values for each attribute.

ב. Given: the class **TvWeek**, which has two attributes. These attributes are a one-dimensional array arrProg that is 100 in size and of type **TvProgram**, and the number of programs currently shown each week – current – which is an integer whose value is smaller than the size of the array.

Assume that for each attribute, get and set methods are defined in Java and Get and Set methods are defined in C#.

(1) Using Java or C#, write the declaration of the class **TvWeek** and its attributes.

(2) Using Java or C#, write a method in the class **TvWeek** that will accept a **TvProgram**, add that program to the programs for the week and update the current number of programs broadcast each week.

Assume that there is room to add the TV program.

(3) Using Java or C#, write a method in the class **TvWeek** that will return the number of sports-related programs shown on television each week.

/Continued on page 6/

Part Two (50 points)

Note: For each question that requires implementation, you may use the methods of the classes queue, stack, binary tree and link, without implementing them. If you use any additional methods, you must implement those additional methods.

Answer <u>two</u> of the questions 4-6 (each question — 25 points).

4. The class **Ring** is shown below. This class has two attributes: the size of the ring, which is a string ("S" — small ring; "L" — large ring), and an integer that represents the color of the ring.

Java

```
public class Ring
{
   private String size;  // ring size
   private int color; // ring color
   public Ring()
   {
      this.size = "L";
      this.color = 0;
   }
   public Ring(String str, int c)
   {
      this.size = str;
      this.color = c;
   }
   public String getSize()
   {
      return this.size;
   }
   public int getColor()
   {
      return this.color;
   }
}
```

C#

```
public class Ring
{
   private string size;  // ring size
   private int color; // ring color
   public Ring()
   {
      this.size = "L";
      this.color = 0;
   }
   public Ring(string str, int c)
   {
      this.size = str;
      this.color = c;
   }
   public string GetSize()
   {
      return this.size;
   }
   public int GetColor()
   {
      return this.color;
   }
}
```

/Continued on page 7/

The interface for the class **Pole** is shown below.

Java	C#	Method
public Pole()	public Pole()	Method that constructs an empty pole. The run-time complexity of the method is O(1).
public void add(Ring r)	public void Add(Ring r)	Method that adds a ring r at the top of the pole. The run-time complexity of the method is O(1).
public Ring remove()	public Ring Remove()	Method that returns the ring that is at the top of the pole. The method also removes the ring from the top of the pole. The run-time complexity of the method is O(1).
public boolean isEmpty()	public bool IsEmpty()	If the pole is empty, the method will return true ; otherwise, it will return false. The run-time complexity of the method is O(1).
public void sort()	public void Sort()	Method that arranges the rings on the pole so that the large rings are at the bottom of the pole underneath the small rings.

א. Implement the method sort() in Java or Sort() in C#, in the class **Pole**. You may use other methods of the class **Pole** without implementing them.

In your answer, use only methods from the classes **Pole** and **Ring**.

ב. What is the run-time complexity of the method you implemented for Item א? Explain your answer.

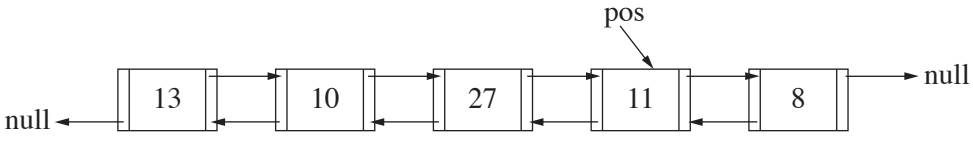
/Continued on page 8/

5.

Note: There are two versions of this question — a version in Java on pages 8-9 and a version in C# on pages 10-11. Work according to the language that you studied.

For those working in Java

We will define a **bidirectional list** as an ordered collection of links of type BinNode<Integer> that are connected to one another such that:
for each pair of links p2, p1 in the list, if p1.getRight() = = p2 , then p2.getLeft() = = p1 . In a **bidirectional list**, there are at least two links. That is, each link in the list — except for the link on the far right end of the list and the link on the far left end of the list — points to the link that precedes it and the link that comes after it.
A sample **bidirectional list** and a variable pos of type BinNode<Integer> that points to a link in a bidirectional list are shown below.



The method firstLeft accepts a pointer pos that is different from null , of type BinNode<Integer> and points to a link in the bidirectional list.
The method returns the link on the far left end of the list.
The method firstRight accepts a pointer pos that is different from null , of type BinNode<Integer> and points to a link in the bidirectional list.
The method returns the link on the far right end of the list.

א. A skeleton of the method firstLeft is shown below.
Copy it into your answer booklet and fill in the blanks, so that the method will do what is asked.

```
public static BinNode<Integer> firstLeft(BinNode<Integer> pos)
{
    while (_____ )
        pos = _____ ;
    return _____ ;
}
```

/Continued on page 9/

ב. The method what(BinNode<Integer> pos) that receives a pointer for a link in a **bidirectional list** and returns a boolean value is shown below. The **bidirectional list** contains at least 3 links.

(1) Trace the execution of the method for the variable pos and the list presented as an example at the beginning of this question.
In your trace, show the bidirectional list and the values of the variables pos , left , right and sum .

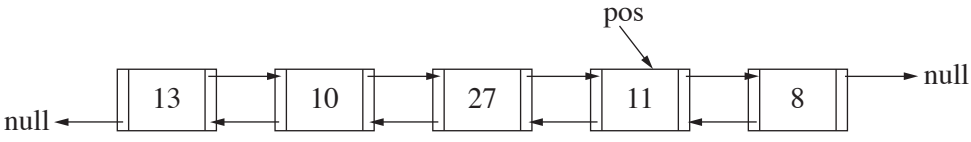
```
public static boolean what(BinNode<Integer> pos)
{
    BinNode<Integer> left = firstLeft(pos);
    BinNode<Integer> right = firstRight(pos);

    int sum = left.getValue() + right.getValue();
    left = left.getRight();
    right = right.getLeft();

    while ((left != right) && (left.getRight() != right) &&
           (left.getValue() + right.getValue() == sum))
    {
        left = left.getRight();
        right = right.getLeft();
    }
    if (left == right)
        return right.getValue() == sum;

    if (left.getRight() == right)
            return left.getValue() + right.getValue() == sum;
    return false;
}
```

(2) Determine whether or not it is possible to replace the last 3 lines of the method — the lines in the box — with the following command:
return left.getValue() + right.getValue() == sum;
Explain your answer.

/Continued on page 10/

For those working in C#

We will define a **bidirectional list** as an ordered collection of links of type BinNode<Int> that are connected to one another such that:
for each pair of links p1, p2 , if p1.GetRight() = = p2 , then p2.GetLeft() = = p1.
In a **bidirectional list**, there are at least two links.
That is, each link in the list — except for the link on the far right end of the list and the link on the far left end of the list — points to the link that precedes it and the link that comes after it.
A sample **bidirectional list** and a variable pos of type BinNode<int> that points to a link in a bidirectional list are shown below.



The method FirstLeft accepts a pointer pos that is different from null , of type BinNode<Int> and points to a link in the bidirectional list.
The method returns the link on the far left end of the list.
The method FirstRight accepts a pointer pos that is different from null , of type BinNode<Int> and points to a link in the bidirectional list.
The method returns the link on the far right end of the list.

א. A skeleton of the method FirstLeft is shown below.
Copy it into your answer booklet and fill in the blanks, so that the method will do what is asked.

```
public static BinNode<int> FirstLeft(BinNode<int> pos)
{
    while (_____ )
        pos = _____ ;
    return _____ ;
}
```

/Continued on page 11/

ב. The method What(BinNode<int> pos) that receives a pointer for a link in a **bidirectional list** and returns a boolean value is shown below.
The **bidirectional list** contains at least 3 links.

(1) Trace the execution of the method for the variable pos and the list presented as an example at the beginning of this question.
In your trace, show the bidirectional list and the values of the variables pos , left , right and sum .

```
public static bool What(BinNode<int> pos)
{
    BinNode<int> left = FirstLeft(pos);
    BinNode<int> right = FirstRight(pos);

    int sum = left.GetValue() + right.GetValue();
    left = left.GetRight();
    right = right.GetLeft();

    while ((left != right) && (left.GetRight() != right) &&
           (left.GetValue() + right.GetValue() == sum))
    {
        left = left.GetRight();
        right = right.GetLeft();
    }
    if (left == right)
        return right.GetValue() == sum;

    if (left.GetRight() == right)
            return left.GetValue() + right.GetValue() == sum;
    return false;
}
```

(2) Determine whether or not it is possible to replace the last 3 lines of the method — the lines in the box — with the following command:
return left.GetValue() + right.GetValue() == sum;
Explain your answer.

/Continued on page 12/

6. An **integer tree** is a non-empty binary tree of integers, in which the values of the nodes are integers greater than 0 that are all different from one another.

The method "increasing-path" is defined for an **integer tree**. This method will return true if the tree includes a path that begins at its root and ends at one of its leaves and the node values are arranged in ascending order from the root to the leaf.

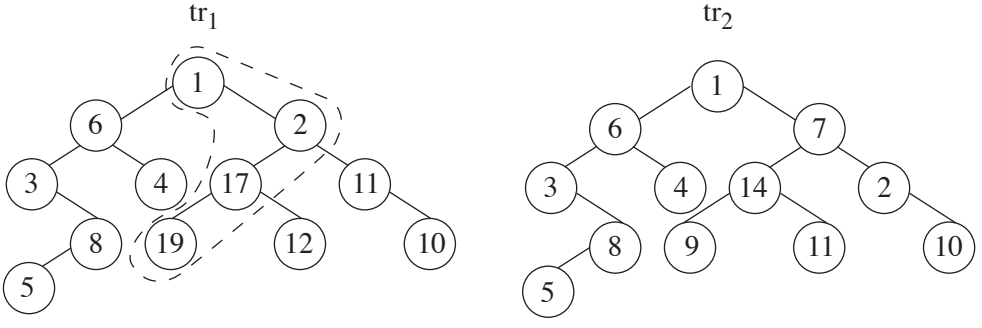
If there is no such path, the method will return false .

For example:

For the **integer tree** tr1, the method "increasing-path" returns true .

The path is indicated by a broken line.

For the **integer tree** tr2, the method "increasing-path" returns false .



Using Java or C#, implement the method "increasing-path" for the **integer tree** tr.

Method declaration in Java: public static boolean upPath(BinNode<Integer> tr)

Method declaration in C#: public static bool UpPath(BinNode<int> tr)

/Continued on page 13/

Part Three (25 points)

Part Three includes questions in four tracks:
Computer Systems and Assembly Language, pp. 13-16,
Introduction to Operations Research, pp. 17-20,
Computational Models, p. 21,
Object-Oriented Programming in Java, pp. 22-26, and Object-Oriented Programming in C#, pp. 27-31.
Answer one question for the track in which you studied.

Computer Systems and Assembly Language

If you studied in this track, answer one of the questions 7-8. (25 points)

7. This question includes two unrelated items, א-ב. Answer both of them.

א. Using Assembly language, write a program segment to encrypt a character.

In the data segment, the character is defined as:

```
TAV     DB ?
```

The encryption is done as follows:

The lit bits in the character are counted.

If there are an even number of lit bits, the bits in the character are rotated to the right. The number of times they are rotated is equal to the number of lit bits.

If there are an odd number of lit bits, the bits in the character are rotated to the left. The number of times they are rotated is equal to the number of lit bits.

ב. (No relation to Item א.)

Determine whether each of the statements below (1)-(6) is true or false. If the statement is false, explain why.

(1) A program segment in Assembly language is shown below.

```
MOV  AX , 8
MOV  BX , 2
DIV  BX
```

Upon the completion of the program segment, the register AX will definitely contain 4.

(Note: This item continues on the next page.)

/Continued on page 14/

(2) A program segment in Assembly language is shown below.

```
        MOV     AL , 56
        ADD     AL , 200
        JZ      STOP
        INC     AL
STOP:
```

Upon the completion of the program segment, the register AX will contain 1.

(3) A program segment in Assembly language is shown below.

```
ARRAY   DW 1, 2, 3, 4
        MOV     BX , ARRAY
        ADD     BX , 2
        MOV     AX , [BX]
```

Upon the completion of the program segment, the register AX will contain 3.

(4) A program segment in Assembly language is shown below.

```
        MOV     CX , 3
        MOV     AX , 1
DO:
        SHL     AX , 1
        LOOP    DO
```

Upon the completion of the program segment, the register AX will contain 8.

(5) A program segment in Assembly language is shown below.

```
MOV  AX , 11000001B
MOV  BX , 01000001B
```

The number in AX must be greater than the number in BX.

(6) A command is shown below.

```
OR   AL , 3
```

After this command is executed, the value of AL will always be odd.

/Continued on page 15/

8. This question is made up of two unrelated items, א and ב. Answer both of them.

א. In a data section, data are defined as follows:

```
VEC1   DB  45H , 26H , 32H , 82H
VEC2   DB  4 DUP(0)
```

A segment of a program in Assembly language is shown below.

```
START:   MOV   CL , 4
         XOR   CH , CH
         XOR   SI , SI
NEXT:    PUSH  CX
         MOV   AL , VEC1[SI]
         MOV   AH , AL
         AND   AL , 0FH
         MOV   CL , 4
         SHR   AH , CL
         MUL   AH        ;(*)
         MOV   VEC2[SI] , AL
         INC   SI
         POP   CX
         LOOP  NEXT
SOF:     NOP
```

(1) Using a trace table, trace the execution of the program segment and sketch VEC2 after it has been executed.
Your trace table should include a column for each of the registers [אוגרים] AL, AH, CL, CH and SI.
Draw the stack [מחסנית] at each stage.

(2) What does the program segment do?

(3) In the program segment, in place of the command marked with an asterisk (*), the following command was written: IMUL AH .
Will this change what the program segment does? Explain your answer.

(Note: This question continues on the next page.)

/Continued on page 16/

ב. The number 2 is stored in Register AL and the number 5 is stored in Register BL.

The sum of the numbers from AL through BL (inclusive) should be stored in Register DX.

Three segments in Assembly language, i-iii, are shown below. Using a trace table, trace the execution of each segment and determine whether or not it did what was asked.

i

```
        MOV    DX , 0
        MOV    AH , 0
        MOV    CL , AL
        SUB    CL , BL
AGAIN:  ADD    DX , AX
        INC    AL
        LOOPE  AGAIN
        NOP
```

ii

```
        XOR    DX , DX
        MOV    BH , 0
AGAIN:  ADD    DX , BX
        DEC    BL
        CMP    BL , AL
        JGE    AGAIN
        NOP
```

iii

```
        XOR    DX , DX
        XOR    AX , AX
        MOV    BX , 0
AGAIN:  ADD    DX , AX
        ADD    AX , 1
        CMP    AX , BX
        JL     AGAIN
        NOP
```

/Continued on page 17/

Introduction to Operations Research

If you studied in this track, answer one of the questions 9-10. (25 points)

9. A given linear programming problem:

$\max\{z = (2 + 2k)x_1 + 2x_2\}$

is subject to the following constraints:

(1) $2x_1 + x_2 \leq 10$

(2) $x_1 + x_2 \leq 6$

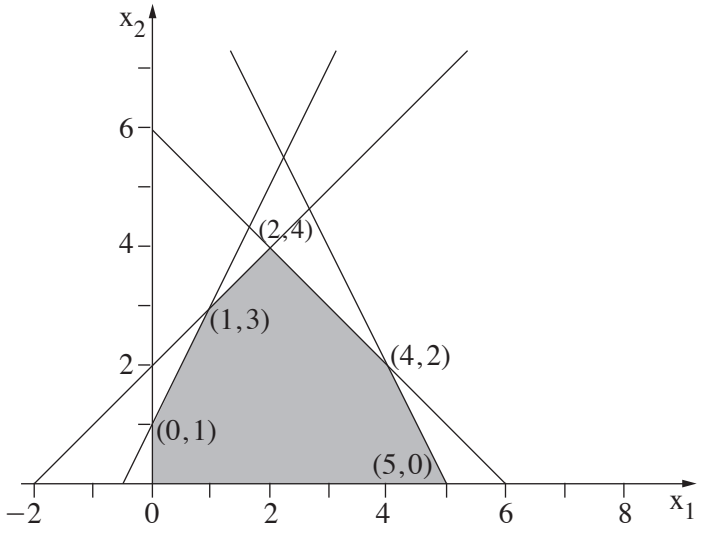
(3) $-x_1 + x_2 \leq 2$

(4) $-2x_1 + x_2 \leq 1$

$x_1 \geq 0$

$x_2 \geq 0$

A sketch of the range of possible solutions for the problem is shown below.



(Note: This question continues on the next page.)

/Continued on page 18/

Each of the items below, א-ד, refers to the given linear programming problem. Each item is independent of the others. Answer all of the items.

א. The two sub-items below, (1)-(2), are **independent of one another**.
In each item, a particular value is given for the parameter k.

(1) $k = -1$

(2) $k = -3$

For each of the sub-items (1)-(2), four statements, i-iv, are given below:

i There is a single optimal solution.

ii There are an infinite number of optimal solutions.

iii The optimal solution is not bounded [לא חסום].

iv There is no optimal solution.

Only one of the statements i-iv is correct for each sub-item.

For each of the sub-items (1)-(2), determine which statement is correct, copy that statement into your answer booklet and explain your decision.

— If you determined that Statement i is correct, find the single optimal solution for that sub-item and the value of the objective function for the solution you found.

— If you determined that Statement ii is correct, find the general optimal solution for the problem and the value of the objective function within the range of optimal solutions.

ב. For which values of k will $(2, 4)$ be the optimal solution of the linear programming problem given at the beginning of this question? Explain your answer.

ג. The constraint $x_1 \geq 0$ is removed from the problem given at the beginning of the question, so that $-\infty \leq x_1 \leq \infty$.
Is there a value of k for which the optimal solution will be unbounded? Explain your answer.

ד. In place of the constraint $x_2 \geq 0$ presented for the given problem at the beginning of this question, the constraint $x_2 \geq 4$ was written.
Once the constraint has been changed, does the problem have an optimal solution? If it does, write the solution. If it does not, explain why there is no optimal solution.

/Continued on page 19/

10. This question is made up of three unrelated items, א-ג. Answer all three of them.

א. G = (V, E) is a **directed** graph that is represented by this adjacency matrix:

	a	**b**	**c**	**d**	**e**
a	0	1	1	0	0
b	0	0	0	1	0
c	0	1	0	0	0
d	0	0	1	0	1
e	0	1	0	0	0

(1) Sketch the graph G that is represented by the matrix.

(2) Find the strong connected components in the given graph. List the set of vertices for each strong connected component.

(3) For the given graph, find the shortest cycle that contains an even number of edges [קשתות] and sketch that cycle in your answer booklet.

(4) What is the minimum number of edges that can be added to the given graph so that the graph will have only one strong connected component? What edge or edges should be added?

ב. The table below shows part of a possible basic solution to the transport problem: $x_{11} = 10$.

Origins	**Destinations**				**Supply**
	1	2	3	4	
1	20 (10)	20	30	21	20
2	22	17	29	30	30
3	10	24	26	38	10
Demand	10	20	20	10	

(1) Copy the table into your answer booklet and then complete the possible basic solution according to the north-west corner method.

(2) The price in Cell (3, 1) is changed from 10 to 20. Will this change the possible basic solution you found for Sub-item **(1)**? Explain.

(Note: This question continues on the next page.)

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ג. The table below shows a possible basic solution for a transport problem and the value of u_3 for that solution.

Origins	**Destinations**			**Supply**	u_i
	1	2	3		
1	10	8	3 (10)	10	
2	12	15	9 (3)	3	
3	2 (20)	7 (40)	1 (30)	90	0
Demand	20	40	43		
v_j					

(1) Copy the table into your answer booklet and fill in the values for u_1, u_2, v_1, v_2 and v_3.

(2) Explain why the given solution is not an optimal solution.

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Computational Models

If you studied in this track, answer one of the questions 11-12. (25 points)

11. The regular languages L_1 and L_2 are shown below.

$L_1 = \{a^{2n} \mid n \geq 0\}$ over the alphabet {a}

$L_2 = \{b^{2n+1} \mid n \geq 0\}$ over the alphabet {b}

Given: the language L over the alphabet {a, b}

$L = \{a^n b^k \mid n \geq 0\ ,\ k \geq 0\ ,$ n is even and k is odd or n is odd and k is even$\}$

א. Using only the languages L_1 and L_2 and closure properties, prove that Language L is regular.

ב. Build a non-deterministic finite automaton that will accept Language L.

12. Given: a method written in Java and in C#.

The method accepts three integers greater than 0.

Java

```
public static int foo(int x , int y , int z)
{
    if ((x % 3) == 0) return x;
    if ((x % 3) == 1) return y;
    return z;
}
```

C#

```
public static int Foo(int x , int y , int z)
{
    if ((x % 3) == 0) return x;
    if ((x % 3) == 1) return y;
    return z;
}
```

Write a Turing machine that will implement the given method.

The input for the machine is the three numbers x, y and z that the method accepts and this input is written on a tape, starting from the beginning.

Each number is written in a unary manner. The numbers are separated by the symbol #.

For example, if the method receives 2 for x, 3 for y and 1 for z, the tape will look like this:

⊢	1	1	#	1	1	1	#	1	△	△	△	.....

↑

read/write head

The output is the value that the method returns and it will be written as a unary value on the tape at some point between two $ signs.

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Object-Oriented Programming

If you studied in this track and are working in Java, answer one of the questions 13-14. (25 points)

13. This question is made up of two independent items, א-ב. Answer both of them.

א. Five classes are given: B, X, Y, Z and Run. The sub-items (1)-(4) below refer to these classes. The sub-items are independent of one another. Answer all of them.

(1) The following method is defined in each of the classes B, X, Y and Z: `public void foo() {}`
and the following method is defined in the class Run:
`public void bar (Object g) {g.foo(); }`
Will there be a compilation error? If so, explain why.

(2) Assume that the classes X, Y and Z inherit the class B.
The following method is defined in each of the classes X, Y and Z:
`public void foo() {}`
and the following method is defined in the class Run:
`public void bar(B g) {g.foo(); }`
Will there be a compilation error? If so, explain why.

(3) Assume that the classes X, Y and Z inherit the class B.
The following method is defined in each of the classes B, X, Y and Z: `public void foo() {}`
and the following method is defined in the class Run:
`public void bar(B g) {g.foo(); }`
Will there be a compilation error? If so, explain why.

(4) Assume that the classes X, Y and Z inherit the class B.
The following method is defined in each of the classes B, X, Y and Z: `public void foo() {}`
and the following method is defined in the class Run:
`public void bar(Object g) {g.foo(); }`
Will there be a compilation error? If so, explain why.

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ב. (No relation to Item א.)
The class **Singer** that inherits the class **Artist**, and the interface **IPerform** that is implemented by the class **Singer** are presented below.

```
interface IPerform
{
   void act();
   int train();
}
public class Singer extends Artist implements IPerform
{
      private int hits;
      public Singer(String name, double sal)
      {
            super(sal, name);
            this.hits = 5;
      }
      public Singer(double sal, int hits)
      {
            super(sal, "Singer Name");
            this.hits = hits;
      }
      public Singer(int hits)
      {
            super(6532.6, "Some", "One");
            this.hits = hits;
      }
      public double value() {return this.hits * this.price();}
      public int getNum()    {return Artist.num;                    }
      public double calc(double d)   {return d * super.calc(10.2);   }
      public void print()      {super.print(); System.out.println("Singer");}
      public void act()        {System.out.println("I am singing");   }
}
```

Using Java, write the declaration of the class **Artist**, the attributes of that class and the method declarations in class **Artist** that are required by the given class **Singer** and the given interface **IPerform**. You do not need to implement the methods of the class **Artist**.
Do not change the class **Singer** or the interface **IPerform**.

/Continued on page 24/

14. The classes A and B are shown below.

The three items א-ג refer to these classes, but are independent of one another. Answer all three items.

```
public class A    {
      private int x;
      public A()                { this.x = 0;        }
      public A(int x)           { this.x = x;                }
      public int getX()         { return x;                  }
      public void doubleX()     { this.x = 2 * getX();       }
      public void tripleX()     { this.x = 3 * getX();       }
      public void sub()         { this.x = x−1;              }
      public void calc()        { sub();                     }
      public String toString()     { return "xA="+this.x;  }
}
public class B extends A  {
      private int x;
      public B()                    { super();   this.x = 1;              }
      public B(int x)               { super(x);  this.x =−x;              }
      public B(int xA, int xB)      { super(xA); this.x = xB;             }
      public int getX()             { return x;                           }
      public int baseX()            { return super.getX();                }
      public void tenTimesX()       { this.x = 10 * getX();               }
      public void tripleX()         { this.x = 3 * getX();                }
      public void sub()             { this.x = x−2;                       }
      public String toString()      { return super.toString()+" xB="+this.x+";";      }
}
```

/Continued on page 25/

א. A series of commands is shown below, for which the output should be:

xA=1 xB=20; xA=1 xB=20; xA=1 xB=20; xA=1 xB=20;

There is a compilation error in the series of commands. Fix the error so that the correct output will be obtained.

```
A a1 = new B(1, 20);
Object obj = a1;
B b1 = a1;
A a2 = a1;
System.out.println(a1+" "+obj+" "+a2+" "+b1);
```

ב. A series of commands is shown below. Present the objects that are produced and the values of the attributes of each object.

```
A aa = new B(3, 10);
aa.sub();
Object[] ar = new Object[6];
ar[0] = new A();
ar[1] = new A(5);
ar[2] = new B();
ar[3] = new B(5);
ar[4] = new B(2, 4);
ar[5] = aa;
((A)ar[3]).tripleX();
((B)ar[4]).tenTimesX();
```

(Note: This question continues on the next page.)

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ג. A main method is shown below.

```
public static void main(String[] args)
{
      A a1 = new A(1);
      A a2 = new B(2, 99);
      //***
}
```

Segments (i)-(vi) are shown below.

(i)
```
a2.doubleX();
System.out.println(a2);
```

(ii)
```
a2.tenTimesX();
System.out.println(a2.tenTimesX());
```

(iii)
```
if (a2 instanceof B)
{
  a2.tenTimesX();
  System.out.println(a2);
}
```

(iv)
```
((B)a1).tenTimesX();
System.out.println(a1);
```

(v)
```
a2.calc();
System.out.println(a2);
```

(vi)
```
B bb = (B)a2;
System.out.println(bb.baseX());
```

For each of the segments (i)-(vi):

— Write the segment in place of //*** in the main method.

— Determine whether or not the segment is valid.

— If the segment is valid, write the output that will be produced once it has been executed.

If the segment is not valid, is the error a compilation error or a run-time error?

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Object-Oriented Programming

If you studied in this track and are working in C#, answer one of the questions 15-16. (25 points)

15. This question is made up of two independent items, א-ב. Answer both of them.

א. Five classes are given: B, X, Y, Z and Run. The sub-items (1)-(4) below refer to these classes. The sub-items are independent of one another. Answer all of them.

(1) The following method is defined in each of the classes B, X, Y and Z: `public virtual void Foo(){}`
and the following method is defined in the class Run:
`public void Bar(Object g) {g.Foo(); }`
Will there be a compilation error? If so, explain why.

(2) Assume that the classes X, Y and Z inherit the class B.
The following method is defined in each of the classes X, Y and Z:
`public virtual void Foo() {}`
and the following method is defined in the class Run:
`public void Bar(B g) {g.Foo(); }`
Will there be a compilation error? If so, explain why.

(3) Assume that the classes X, Y and Z inherit the class B.
The following method is defined in each of the classes B, X, Y, and Z: `public virtual void Foo(){}`
and the following method is defined in the class Run:
`public void Bar(B g) {g.Foo(); }`
Will there be a compilation error? If so, explain why.

(4) Assume that the classes X, Y and Z inherit the class B.
The following method is defined in each of the classes B, X, Y and Z: `public virtual void Foo() {}`
and the following method is defined in the class Run:
`public void Bar(Object g) {g.Foo(); }`
Will there be a compilation error? If so, explain why.

(Note: This question continues on the next page.)

/Continued on page 28/

ב. (No relation to Item א.)

The class **Singer** that inherits the class **Artist**, and the interface **IPerform** that is implemented by the class **Singer** are presented below.

```
interface IPerform
{
    void Act();
    int Train();
}
public class Singer : Artist , IPerform
{
    private int hits;
    public Singer(string name, double sal) : base(sal, name)
    {
        this.hits = 5;
    }
    public Singer(double sal, int hits) : base(sal, "Singer Name")
    {
        this.hits = hits;
    }
    public Singer(int hits) : base(6532.6, "Some", "One")
    {
        this.hits = hits;
    }
    public double Value()          {return this.hits * this.Price(); }
    public int GetNum()            {return Artist.num;               }
    public override double Calc(double d)  {return d * base.Calc(10.2); }
    public override void Print()   {base.Print(); Console.WriteLine("Singer");   }
    public void Act()              {Console.WriteLine("I am singing");          }
}
```

Using C#, write the declaration of the class **Artist**, the attributes of that class and methods in class **Artist** that are required by the given class **Singer** and the given interface **IPerform**. You do not need to implement the methods of the class **Artist**.

Do not change the class **Singer** or the interface **IPerform**.

/Continued on page 29/

16. The classes A and B are shown below.
The three items א-ג refer to these classes, but are independent of one another. Answer all three items.

```
public class A    {
      private int x;
      public A()                        { this.x = 0;              }
      public A(int x)                   { this.x = x;              }
      public virtual int GetX()         { return x;                }
      public void DoubleX()             { this.x = 2 * GetX();     }
      public virtual void TripleX()     { this.x = 3 * GetX();     }
      public virtual void Sub()         { this.x = x-1;            }
      public void Calc()                { Sub();                   }
      public override string ToString(){ return "xA="+this.x;  }
}
public class B:A  {
      private int x;
      public B() : base()               { this.x = 1;              }
      public B(int x) : base(x)         { this.x =-x;              }
      public B(int xA, int xB) : base(xA)       { this.x = xB;     }
      public override int GetX()        { return x;                }
      public int BaseX()                { return base.GetX();      }
      public void TenTimesX()           { this.x = 10 * GetX();    }
      public override void TripleX()  { this.x = 3 * GetX();     }
      public override void Sub()        { this.x = x-2;            }
      public override string ToString(){ return base.ToString()+" xB="+this.x+";";}
}
```

(Note: This question continues on the next two pages.)

/Continued on page 30/

א. A series of commands is shown below, for which the output should be:
xA=1 xB=20; xA=1 xB=20; xA=1 xB=20; xA=1 xB=20;
There is a compilation error in the series of commands. Fix the error so that the correct output will be obtained.

```
A a1 = new B(1, 20);
Object obj = a1;
B b1 = a1;
A a2 = a1;
Console.WriteLine(a1+" "+obj+" "+a2+" "+b1);
```

ב. A series of commands is shown below. Present the objects that are produced and the values of the attributes of each object.

```
A aa = new B(3, 10);
aa.Sub();
Object[] ar = new Object[6];
ar[0] = new A();
ar[1] = new A(5);
ar[2] = new B();
ar[3] = new B(5);
ar[4] = new B(2, 4);
ar[5] = aa;
((A)ar[3]).TripleX();
((B)ar[4]).TenTimesX();
```

/Continued on page 31/

ג. A main method is shown below.

```
public static void Main()
{
    A a1 = new A(1);
    A a2 = new B(2, 99);
    //***
}
```

The segments (i)-(vi) are shown below.

(i)
```
a2.DoubleX();
Console.WriteLine(a2);
```

(ii)
```
a2.TenTimesX();
Console.WriteLine(a2.TenTimesX());
```

(iii)
```
if (a2 is B)
{
   a2.TenTimesX();
   Console.WriteLine(a2);
}
```

(iv)
```
((B)a1).TenTimesX();
Console.WriteLine(a1);
```

(v)
```
a2.Calc();
Console.WriteLine(a2);
```

(vi)
```
B bb = (B)a2;
Console.WriteLine(bb.BaseX());
```

For each of the segments (i)-(vi):

— Write the segment in place of //*** in the main method.

— Determine whether or not the segment is valid.

— If the segment is valid, write the output that will be produced once it has been executed.
If the segment is not valid, is the error a compilation error or a run-time error?

Good Luck!

בהצלחה!