

Computer Science

Reform for Meaningful Learning Program

Instructions for examinees

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

Good Luck!

מדעי המחשב

על פי תכנית הרפורמה ללמידה משמעותית

הוראות לנבח

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.
 $(10 \times 1) + (15 \times 1) = 25$ נקודות
פרק שני – בפרק זה יש שלוש שאלות, ומהן עליך לענות על שתיים.
 $(25 \times 2) = 50$ נקודות
פרק שלישי – בפרק זה שאלות בארבע מסלולים שונים.
ענה על שאלה אחת במסלול שלמדת.
 $(25 \times 1) = 25$ 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 המסלול 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 בטיוטה (ראשי פרקים, חישובים וכדומה). רשום "טיוטה" בראש כל עמוד טיוטה. רישום טיוטות כלשהן על דפים מחוץ למחברת הבחינה עלול לגרום לפסילת הבחינה!

בהצלחה!

Questions

This exam has three parts.

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

Part One (25 points)

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

For those working in Java: For each question that requires input, assume that the following command is written in the program:

Scanner input = new Scanner (System.in);

Answer Question 1 — Required (10 points).

1. Write an external method `big` in Java or `Big` in C# that accepts an array of integers. The method will return the index of the element with the largest value in the array. If this number appears more than once in the array, the method will return the smallest such index.

Answer one of the Questions 2-3 (each question—15 points).

2. In preparation for international sports games, a class **Game** was defined, with three attributes: `gameName` – the name of the game – a string type, `numPlayers` – the number of players – an integer type, and `isWater` – whether the game is played in water – a boolean type. Assume that for each attribute, `set` and `get` methods are defined in Java and `Set` and `Get` methods are defined in C#.
 - ⌘. Using Java or C#, write a constructor method in class **Game** that accepts values for each attribute.
 - ⌘. A class **Country** was defined, with two attributes: `countryName`, of string type, and a one-dimensional array – `games`, of size 43 of type **Game**. The array contains the games in which the country is participating. Assume that for each attribute, `set` and `get` methods are defined in Java and `Set` and `Get` methods are defined in C#.
 - (1) Using Java or C#, write the declaration of the class **Country** and its attributes.
 - (2) Using Java or C#, write a constructor method in the class **Country** that will accept the country name. The method will construct an object for a country that does not participate in any game.
 - (3) Using Java or C#, write a boolean method in the class **Country** that accepts the game name and returns `true` if the country plays in the game. Otherwise, the method returns `false`.

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3. A code fragment written in Java and C# is shown below.

Java	C#
<pre> int i , j; for (i = 1; i <= n; i++) { a[i] = i; } for (i = 2; i < n; i++) { if (a[i] != 0) { for (j = i + 1; j <= n; j++) { if (a[j] % a[i] == 0) { a[j] = 0; } } } } for (i = 1; i <= n; i++) { if (a[i] != 0) { System.out.println(a[i]); } } </pre>	<pre> int i , j; for (i = 1; i <= n; i++) { a[i] = i; } for (i = 2; i < n; i++) { if (a[i] != 0) { for (j = i + 1; j <= n; j++) { if (a[j] % a[i] == 0) { a[j] = 0; } } } } for (i = 1; i <= n; i++) { if (a[i] != 0) { Console.WriteLine(a[i]); } } </pre>

- א. What will be printed for $n = 15$?
- ב. Write in one sentence what this code fragment does, that is, formulate the problem for which this code fragment is the solution.

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 methods.

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

4. Five methods that operate on any data structure are defined below.

Note: The method names below are not written in Java or C#.

- `insert(x)` – a method that inserts into the structure an element whose value is the integer `x`.
- `showMin()` – a method that returns the smallest value in the structure, without changing the structure.
- `getMax()` – a method that returns the element whose value is largest and removes it from the structure. If there is more than one such element, the method will return and remove the first one.
- `exists(x)` – a boolean method that returns `true` if an element of value `x` exists in the structure. Otherwise, the method returns `false`.
- `div7()` – a boolean method that returns `true` if the structure contains an element whose value is divisible by 7. Otherwise, the method returns `false`.

We shall want to suggest data structures that meet various complexity requirements on implementation of some of these five methods.

Example: We want to suggest a data structure on which the methods `insert` and `showMin` execute in complexity $O(1)$, and the methods `getMax` and `exists` execute in complexity $O(n)$. For this purpose, we shall define a data structure and explain how the methods will be implemented.

Note: In this structure, there is no need to consider the method `div7`.

An appropriate data structure is composed of:

- A doubly-linked list of integers, `lst`.
- A pointer to the smallest element in the list, `min`.

The methods will be executed in the following way:

Method	Implementation	Why the implementation meets the complexity requirements
insert(x)	— Insert <code>x</code> at the head of the list. — If the element is smaller than the minimum till now, update the pointer <code>min</code> to point to the new element.	— Element insertion at head of list — $O(1)$ — If inserted element is smaller than minimum: updating pointer to minimum element — $O(1)$. — If inserted element is first in list, insertion at head of list in $O(1)$ time + updating pointer to first element, which is also the minimum. Total — $O(1)$.
showMin()	Return the value of the element that <code>min</code> points to.	Returning value — $O(1)$.
exists(x)	Traverse list <code>lst</code> and search for an element of value <code>x</code> .	In the worst case — traversing the entire list — $O(n)$.
getMax()	Traverse list <code>lst</code> , search for the element with the maximum value and remove it from the list.	— Searching for element with maximum value — $O(n)$. — Removal from the list — $O(1)$.

There are two items below, א-ב. For each of the items, propose an appropriate data structure that meets the complexity requirements described in the item. The structure may be composed of a combination of several structures and data types that you studied.

For each method, explain how to implement it and why its implementation meets the requirements (as shown in the table in the example). You do not need to implement the methods.

- א. Execution of the methods `insert` and `exists` in complexity $O(n)$, and execution of the methods `showMin` and `getMax` in complexity $O(1)$.
- ב. Execution of the methods `insert` and `getMax` in complexity $O(n)$, and execution of the method `div7` in complexity $O(1)$.

5. A program written in Java and C# is shown below.

The method `what` in Java and `What` in C# accepts a one-dimensional array of integers, and an integer k , $k > 0$. All numbers in the array are between 0 and k (inclusive).

Java

```
public class Program
{
    public static int[] what(int[] arr, int k)
    {
        int n = arr.length;
        int[] b = new int[n];
        int[] c = new int[k+1];

        for (int i = 0; i < k+1; i++) c[i] = 0;
        for (int j = 0; j < n; j++) c[arr[j]] = c[arr[j]] + 1;    /*

        for (int i = 1; i < k+1 ; i++) c[i] = c[i] + c[i-1];    /**

        for (int j = n-1 ; j >= 0; j--)                          /****
        {
            b[c[arr[j]] - 1] = arr[j];
            c[arr[j]] = c[arr[j]] - 1;
        }
        return b;
    }

    public static void main(String[] args)
    {
        int[] arr = new int[] {5,0,2,1,3,0,5};
        arr = what(arr, 5);
        for (int i = 0; i < arr.length; i++) System.out.println(arr[i]);
    }
}
```

C#

public class Program

{

public static int[] What(int[] arr, int k)

{

int n = arr.Length;

int[] b = new int[n];

int[] c = new int[k+1];

for (int i = 0; i < k+1; i++) c[i] = 0;

for (int j = 0; j < n; j++) c[arr[j]] = c[arr[j]] + 1; /**

for (int i = 1; i < k+1 ; i++) c[i] = c[i] + c[i-1]; /**

for (int j = n-1 ; j >= 0; j--) /**

{

b[c[arr[j]] - 1] = arr[j];

c[arr[j]] = c[arr[j]] - 1;

}

return b;

}

public static void Main(string[] args)

{

int[] arr = new int[] {5,0,2,1,3,0,5};

arr = What(arr, 5);

for (int i = 0; i < arr.Length; i++) Console.WriteLine(arr[i]);

}

}

- א. (1) Sketch the array c after execution of the loop labeled /**.
- (2) Sketch the array c after execution of the loop labeled /***.
- (3) Trace the execution of the loop labeled /***. In the trace, show: j, arr[j], c[arr[j]], b[c[arr[j]]-1], the array b and the array c.
- ב. What does the method what in Java or What in C# do?
- ג. What is the run-time complexity of what in Java or What in C#?

Explain your answer.

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6. א. Implement an external method `exist` in Java or `Exist` in C#. The method accepts a binary tree `t` of integers and an integer `x`. The method returns `true` if the tree has a node whose value is `x`, and returns `false` otherwise. If the tree is empty, the method returns `false`.
- ב. The method `check(t1,t2)` in Java and `Check(t1,t2)` in C# appears below. The method accepts two non-empty binary trees, `t1` and `t2`, that contain integers, and returns a list of all the numbers in tree `t1` that are not in tree `t2`. The method calls another method that accepts three parameters.

Java

```
public static Node<Integer> check(BinNode<Integer> t1, BinNode<Integer> t2)
{
    Node<Integer> first = new Node<Integer> (- 1);
    first = check(t1 , t2 , first);
    return first.getNext();
}
```

C#

```
public static Node<int> Check(BinNode<int> t1 , BinNode<int> t2)
{
    Node<int> first = new Node<int> (- 1);
    first = Check(t1 , t2 , first);
    return first.GetNext();
}
```

Implement the method:

In Java:

```
public static Node<Integer> check(BinNode<Integer> t1,
                                BinNode<Integer> t2 , Node<Integer> list)
```

or in C#:

```
public static Node<int> Check(BinNode<int> t1 , BinNode<int> t2 ,
                             Node<int> list)
```

You may use the method you implemented in Item א.

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

Part Three (25 points)

Part Three includes questions in four tracks:

Computer Systems and Assembly Language, pp. 9-11.

Introduction to Operations Research, pp. 12-16.

Computational Models, p. 17.

Object-Oriented Programming in Java, pp. 18-21;

Object-Oriented Programming in C#, pp. 22-25.

Answer one question for the track that you studied.

Computer Systems and Assembly Language

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

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

- א. Shown below is an Assembly language code fragment in which AH and AL contain different unsigned numbers.

```
MOV  AX , 7F80H
CMP  AH , AL
JL   SMALL
BIG: MOV  BL , AH
      JMP  SOF
SMALL: MOV  BL , AL
SOF:
```

- (1) What will be the value of BL after executing the code fragment?
- (2) What does the code fragment do?
- (3) In the code fragment, the instruction JB SMALL was inserted instead of JL SMALL.

Will the value of BL following execution of the code fragment after the instruction change be different from its value following execution of the code fragment before the instruction change?

Explain your answer.

ב. (Unrelated to Item א.)

Determine whether each of the six statements below is true or false.

If the statement is false, explain why.

(1) $10011110101110_2 > 27AE_{16}$

(2) $27AE_{16} > 10159_{10}$

(3) The functions of registers BP and SP are:

BP determines the address at which a word will be entered into the stack and the address from which a word will be retrieved from it.

SP allows a routine (procedure) to retrieve parameters from the stack, without involving the BP.

(4) After reading and executing each instruction, the value of IP always increments by 1.

(5) Two Assembly language code fragments are shown below.

Fragment 1

MOV DX , 0000H

MOV AX , 0064H

DIV AL

Fragment 2

MOV DX , 0000H

MOV AX , 0064H

DIV AX

After executing both code fragments, the contents of AX will be 0001H.

(6) Two Assembly language code fragments are shown below.

Fragment 1

MOV AL , 5BH

MOV CL , 8

ROL AL , CL

Fragment 2

MOV AL , 5BH

MOV CL , 9

ROL AL , CL

After executing Fragment 1, the value of AL will be equal to the value that was assigned to it in the first instruction, and after executing Fragment 2, the value of AL will also be equal to the value that was assigned to it in the first instruction.

8. Given: two arrays ARR1 and ARR2

The two arrays are of equal size and each of their elements is the size of a word.

Each element in each of the arrays stores a four-digit hexadecimal integer, in the range 1000H-FFFFH.

You are also given a one-byte variable K that stores the size of the arrays ARR1 and ARR2.

Using Assembly language, write a code fragment that stores in register DX the number of pairs of numbers (one from Array ARR1 and the other from Array ARR2) that meet the following conditions:

- (i) Both numbers in the pair have the same index in the array.
- (ii) Both numbers in the pair are composed of the same digits but in reverse order.

Example: For the 5-element arrays ARR1 and ARR2 shown below, the number 2 will be stored in register DX.

ARR1	2025H	1061H	1492H	5777H	1948H
ARR2	1984H	1601H	2914H	9999H	8491H

Introduction to Operations Research

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

9. Given: a linear programming problem

$$\max \{z = 5x_1 - x_2\}$$

subject to the following constraints:

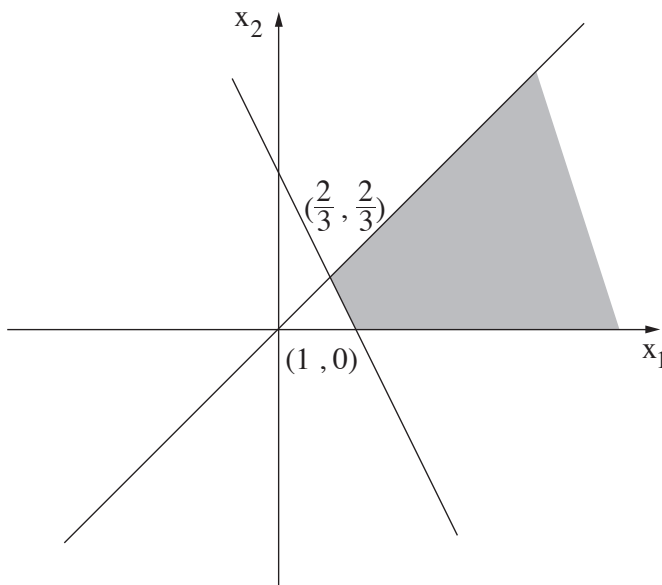
$$x_2 \leq x_1$$

$$2x_1 + x_2 \geq 2$$

$$x_1 \geq 0$$

$$x_2 \geq 0$$

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



Each of the items ה-א on the next page refers to the given linear programming problem. Each item is independent of the others. Answer all of the items.

For each of the items א-ה, four statements, i-iv, are given, and for each item only one statement is correct.

- i There is a single optimal solution.
- ii There is an infinite number of optimal solutions.
- iii The optimal solution is unbounded [לא חסום].
- iv There is no optimal solution.

For each of the items τ - $\aleph$, determine which statement is correct, copy that statement into your answer booklet and explain your decision.

- If you chose Statement i for any item, find the single optimal solution and the value of the objective function for this solution.
 - If you chose Statement ii for any item, find the general optimal solution to the problem and the value of the objective function within the range of optimal solutions.
- $\aleph$. Which statement is true for the linear programming problem given at the beginning of the question? Explain your answer.
- $\beth$. We change only the objective function of the problem given at the beginning of the question to $\max \{z = -5x_1 + x_2\}$.
After changing the objective function, which statement is true? Explain your answer.
- $\aleph$. We change only the objective function of the problem given at the beginning of the question to $\min \{z = -5x_1 + x_2\}$.
After changing the objective function, which statement is true? Explain your answer.
- τ . We change only the objective function of the problem given at the beginning of the question to $\max \{z = -2x_1 + 2x_2\}$.
After changing the objective function, which statement is true? Explain your answer.
- η . We add an additional constraint to the problem given at the beginning of the question: $2x_1 - x_2 \leq 2$
and we change the objective function of the problem given at the beginning of the question to $\max \{z = ax_1 + x_2\}$, where $(-1) < a < 2$, and the maximum value that the objective function receives over the range of possible solutions is 4.
Calculate the value of a.

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

- א. $G = (V, E)$ is an **undirected** graph that is represented by the following adjacency list:

a	→	b	→	c	→	d	→	
b	→	a	→	c	→			
c	→	a	→	b	→			
d	→	a	→	f	→	e	→	
e	→	d	→	f	→			
f	→	e	→	d	→			

- (1) Sketch the graph G that is represented by the adjacency list.
- (2) Is the given graph G a connected graph [גרף קשיר]? Explain.
- (3) Apply a depth-first search (DFS) algorithm on the given graph starting from Vertex a . In your booklet, sketch only the DFS spanning tree that is obtained.
Base your answer on the representation provided by the adjacency list.
- (4) Apply a breadth-first search (BFS) algorithm on the given graph starting from Vertex a . In your booklet, sketch only the BFS spanning tree that is obtained.
Base your answer on the representation provided by the adjacency list.

ב. (Unrelated to Item א.)

- (1) The table below shows part of a possible basic solution to a transport problem and given values of $u_1, u_2, u_3, v_1, v_2, v_3$.

Origins	Destinations			Supply	u_i
	1	2	3		
1	2 20	5	7	20	2
2	1	1 10	4	10	0
3	0	1	8 10	15	0
Demand	20	15	10		
v_j	0	1	8		

Copy the table into your answer booklet and then complete it, taking into account the u_i and v_j values, such that a possible basic solution will be obtained.

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

/Continued on page 16/

- (2) The table below shows a possible basic solution to a transport problem and given values of $u_1, u_2, u_3, v_1, v_2, v_3$.

Origins	Destinations			Supply	u_i
	1	2	3		
1	14	15 (130)	17 (50)	180	0
2	10 (80)	8 (20)	14	100	-7
3	15	20	18 (80)	80	1
Demand	80	150	130		
v_j	17	15	17		

Is the solution optimal? Explain your answer.

- (3) The table below shows a possible basic solution for a transport problem. Given: $v_1 = 0$.

Origins	Destinations			Supply	u_i
	1	2	3		
1	10 (20)	25	30	20	
2	10 (30)	22	14 (20)	50	
3	18	20 (40)	20 (20)	60	
Demand	50	40	40		
v_j	0				

Copy the table into your answer booklet and fill in the values for u_1, u_2, u_3, v_2 and v_3 .

Computational Models

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

11. This question has two unrelated items, א-ב. Answer both of them.

א. Given: a method written in Java or in C#:

Java

```
boolean foo(String str) {
    int cntrA = 0;
    int cntrC = 0;
    for (int i = 0; i < str.length; i++) {
        if (str[i] == 'a') cntrA++;
        if (str[i] == 'c') cntrC++;
    }
    if ((cntrA % 2 == 0) &&
        (cntrC % 3 == 0))
        return true;
    return false;
}
```

C#

```
bool Foo(string str) {
    int cntrA = 0;
    int cntrC = 0;
    for (int i = 0; i < str.Length; i++) {
        if (str[i] == 'a') cntrA++;
        if (str[i] == 'c') cntrC++;
    }
    if ((cntrA % 2 == 0) &&
        (cntrC % 3 == 0))
        return true;
    return false;
}
```

- (1) Write the language L over the alphabet {a, c} that is the set of all words for which the given method returns true.
- (2) Build a deterministic finite automaton that will accept Language L.

ב. (Unrelated to Item א.)

Build a non-deterministic finite automaton over the alphabet {a, b} that will accept all the words in which one of the sequences bbb, aaba, or ababa, appears at least once.

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

$$L = \{a^n b^m c^{n+m} \mid n, m > 0\}$$

- א.** Build a pushdown automaton [אוטומט מחסנית] that will accept Language L.
- ב.** Build a Turing machine that will accept Language L.

Object-Oriented Programming

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

13. The interfaces IOne, ITwo, IThree, and IFour and the classes Alpha, Beta, Gamma, and Program are shown below.

```
public interface IOne {  
    public boolean firstA(Object x);  
    public void firstB(int num);  
}
```

```
public interface ITwo {  
    public int second();  
}
```

```
public interface IThree {  
    public int third();  
}
```

```
public interface IFour {  
    public int fourth();  
}
```

```
public class Alpha implements IOne {}  
public class Beta implements ITwo, IFour {}  
public class Gamma implements ITwo, IThree {}  
public class Program {  
    public static void main(String[] args) {}  
}
```

- ✎ Write the names of the methods that need to be implemented in each of the classes Alpha, Beta, and Gamma, and explain why.

Assume that the methods that you listed in Item 6 have been implemented in each of the classes.

6. Is the definition `public class Omega implements IFour extends Beta { }` correct?

If it is not correct, explain why.

7. Consider each of the following code fragments i-iv: If we inserted this code fragment in the method `main`, would the resulting method `main` be correct or incorrect? Explain your answers.

i `ITwo x1 = new ITwo();`

ii `Beta b = new Beta();`

iii `Alpha a = new Alpha();`
`IOne x2 = a;`

iv `Gamma c = new Gamma ();`
`IOne x3 = c ;`

7. For each of the following requirements i-ii, determine whether it is possible to execute it by writing a command or commands in the method `main`. If it is possible, write the appropriate command or commands. If it is not possible, explain why.

i Invoking the method `second` on an object of type `Beta`.

ii Casting an object of type `Gamma` to an object of type `Alpha`.

14. This question has four unrelated items, ט-א. Answer all of them.

א. Given: Class A, and Class B that inherits from A.

The instruction `A a1 = new B();` compiles and runs correctly.

For each of the following statements i-iii, decide whether the statement is correct or incorrect. Explain your answers.

- i The instruction `Object obj = a1;` cannot be written because explicit casting is required.
- ii The instruction `A a2 = a1;` cannot be written because explicit casting is required.
- iii The instruction `B b1 = a1;` cannot be written because explicit casting is required.

ב. Given: the method `main` in the class `Program`:

```
public static void main(String[] args) {
    C c = new A();
    B b1 = (B) (new A());
    B b2 = new D();
    A a = new D();
}
```

Determine which of the following choices i-v below describes the relationship between the classes, according to the given method `main`.

- i C inherits from A, B inherits from A, D inherits from A.
- ii A inherits from C, B inherits from A, D inherits from A.
- iii C inherits from A, B inherits from A, D inherits from B.
- iv A inherits from C, C inherits from B, D inherits from A.
- v A inherits from C, B inherits from A, D inherits from B, C inherits from B.

- ג. Given: definitions of classes School and City.

```
public class City{ (1) int students; }
public class School extends City {
    void poll() { System.out.println("There are "+ students + " in the school "); }
}
```

In order to prevent a compilation error, you can fill in the part of the line labeled (1) with one of the following choices. Choose the appropriate option and copy it to your notebook.

- Write public, private, or protected.
- Write public or private only.
- Write public or protected only.
- Write protected only.
- Write public only.
- Write private only.

- ד. Given: the definition of the class Quest.

```
public class Quest {
    private int num;
    private static int count = 0;

    public Quest()
    {
        count++;
        num = count;
    }
    public void printNow()
    {
        System.out.println (num + "" + count);
    }
}
```

Determine how many objects of class Quest must be produced, and on which of them the method printNow must be invoked, so that the output will be 35.

Object-Oriented Programming

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

- 15.** The interfaces `IOne`, `ITwo`, `IThree`, and `IFour` and the classes `Alpha`, `Beta`, `Gamma`, and `Program` are shown below.

```
interface IOne {  
    bool FirstA(Object x);  
    void FirstB(int num);  
}
```

```
interface ITwo {  
    int Second();  
}
```

```
interface IThree {  
    int Third();  
}
```

```
interface IFour {  
    int Fourth();  
}
```

```
public class Alpha : IOne {}  
public class Beta : ITwo, IFour {}  
public class Gamma : ITwo, IThree {}  
public class Program {  
    public static void Main() {}  
}
```

- ⌘. Write the names of the methods that need to be implemented in each of the classes `Alpha`, `Beta`, and `Gamma`, and explain why.

Assume that the methods that you listed in Item 6 have been implemented in each of the classes.

6. Is the definition `public class Omega: IFour, Beta { }` correct? If it is not correct, explain why.
7. Consider each of the following code fragments i-iv: If we inserted this code fragment in the method `main`, would the resulting method `main` be correct or incorrect? Explain your answers.
- i `ITwo x1 = new ITwo();`
 - ii `Beta b = new Beta();`
 - iii `Alpha a = new Alpha();`
`IOne x2 = a;`
 - iv `Gamma c = new Gamma ();`
`IOne x3 = c ;`
7. For each of the following requirements i-ii, determine whether it is possible to execute it by writing a command or commands in the method `Main`. If it is possible, write the appropriate command or commands. If it is not possible, explain why.
- i Invoking the method `Second` on an object of type `Beta`.
 - ii Casting an object of type `Gamma` to an object of type `Alpha`.

16. This question has four unrelated items, ט-א. Answer all of them.

א. Given: Class A, and Class B that inherits from A.

The instruction `A a1 = new B();` compiles and runs correctly.

For each of the following statements i-iii, decide whether the statement is correct or incorrect. Explain your answers.

- i The instruction `Object obj = a1;` cannot be written because explicit casting is required.
- ii The instruction `A a2 = a1;` cannot be written because explicit casting is required.
- iii The instruction `B b1 = a1;` cannot be written because explicit casting is required.

ב. Given: the method `Main` in the class `Program`:

```
public static void Main(string[] args) {  
    C c = new A();  
    B b1 = (B) (new A());  
    B b2 = new D();  
    A a = new D();  
}
```

Determine which of the following choices i-v below describes the relationship between the classes, according to the given method `Main`.

- i C inherits from A, B inherits from A, D inherits from A.
- ii A inherits from C, B inherits from A, D inherits from A.
- iii C inherits from A, B inherits from A, D inherits from B.
- iv A inherits from C, C inherits from B, D inherits from A.
- v A inherits from C, B inherits from A, D inherits from B, C inherits from B.

- ג. Given: definitions of classes School and City.

```
public class City{_____(1)____int students; }
public class School : City {
    void Poll() {Console.WriteLine("There are "+ students + " in the school ");}
}
```

In order to prevent a compilation error, you can fill in the part of the line labeled (1) with one of the following choices. Choose the appropriate option and copy it to your notebook.

- Write public, private, or protected.
- Write public or private only.
- Write public or protected only.
- Write protected only.
- Write public only.
- Write private only.

- ד. Given: the definition of the class Quest.

```
public class Quest {
    private int num;
    private static int count = 0;

    public Quest()
    {
        count++;
        num = count;
    }
    public void PrintNow()
    {
        Console.WriteLine(num + " " + count);
    }
}
```

Determine how many objects of class Quest must be produced, and on which of them the method PrintNow must be invoked, so that the output will be 35.

Good Luck!

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