

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2023(2024)  
 கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2023(2024)  
 General Certificate of Education (Adv. Level) Examination, 2023(2024)

තොරතුරු හා සන්නිවේදන තාක්ෂණය II  
 தகவல், தொடர்பாடல் தொழினுட்பவியல் II  
 Information & Communication Technology II

20 E II

\* Answer any four questions only.

### Part B

5. (a) A circuit with three inputs (A, B, C) and one output (Z) is to be designed. The output should be equal to 1 when the binary value combination of the three inputs is either 1, 3 or 6. The output should be 0 for other cases.

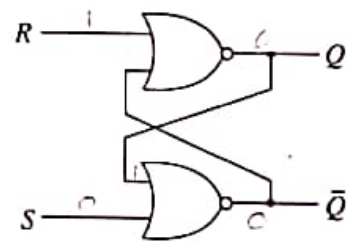
- (i) Draw the complete truth table for the above circuit.  
 (ii) Complete the Karnaugh map relevant to the above circuit according to the following format:

		AB			
		00	01	11	10
C	0				
	1				

- (iii) Using the Karnaugh map, derive the most simplified product-of-sums (POS) expression for the output Z. Show the loops clearly on the Karnaugh map.  
 (iv) Draw a logic circuit for the **simplified** expression derived in (iii) by only using NOR gates assuming that the complemented inputs  $\bar{A}$ ,  $\bar{B}$  and  $\bar{C}$  are also available.
- (b) Using Boolean Algebra show that  $\bar{A}C + \bar{A}B + A\bar{B}C + BC$  is equivalent to  $C + \bar{A}B$ .

- (c) Consider the flip flop circuit shown on the right.

- (i) Assume that the S input is 1 and the R input is 0. What will be the output at Q?  
 (ii) What will be the output at Q if the S input is now made 0?  
 (iii) What will be the output at Q when the R input is now made 1?



6. (a) Draw a sketch to show how a file server (FS), a printer (P), a switch (S) and two computers (C1 and C2) should be connected in a *star topology*.

- (b) A port number is also used along with an IP address in a network communication. Why?

- (c) Consider a subnet with the network address 192.168.56.128/26.

- (i) Write an example IP address that can be assigned to a host attached to this subnet (in dotted decimal notation).  
 (ii) Write the first and the last usable host addresses in this network (in dotted decimal notation).  
 (iii) How many host addresses are available for use in this subnet?

- (d) Suppose an Internet Service Provider owns the 192.168.56.32/26 IP address block. Assume that the provider wants to create four subnets namely, Subnet A, Subnet B, Subnet C and Subnet D from this address block with each subnet having the same number of IP addresses.
- Write the subnet mask of the above given IP address block in dotted decimal notation.
  - Write the number of host bits needed to create the required number of subnets.
  - Once subnetting is done, fill in the following table.

Subnet	Network address	First usable IP address	Last usable IP address	Broadcast address
Subnet A				
Subnet B				
Subnet C				
Subnet D				

- (e) (i) Write **two** functions of a proxy server in a computer network.  
(ii) Write **two** properties of MAC addresses assigned to devices connected to a network.

7. (a) Assume that you are given an Arduino UNO board (Figure 7.1) along with the following items:

- Passive Infrared Sensor (PIR) for motion detection (Figure 7.2)
- Sensor for ambient light detection
- LEDs, Resistors, and a Power supply

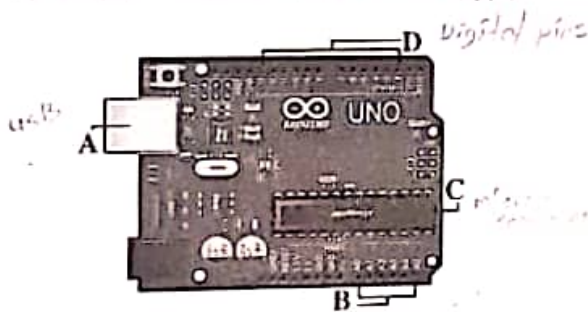


Figure 7.1

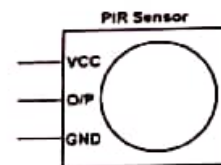


Figure 7.2

- Identify the parts marked as A, B, C, and D in Figure 7.1 and briefly explain each of their functionalities.
  - Assume that you want to build an IoT setup that switches an LED light on when motion is detected. It is further required to switch on this LED only during night time. Draw a schematic diagram connecting the Arduino board and the items given above as necessary in order to build this setup.
- (b) An e-commerce warehouse automation system includes a set of agent-based robots which move ordered goods to their respective dispatch areas to start relevant shipments. The Figure 7.3 shows the latter part of this system. A Quality Control (QC) Officer inspects the goods of each order as it passes on a conveyor belt and confirms to a software system (Delivery Handler Agent) that the order has passed QC. The Delivery Handler Agent directs the package to a mobile robot at the loading area. The robot agent reads the package barcode to determine the appropriate dispatch area. It then navigates the robot to the relevant dispatch area, scanning the path and avoiding obstacles while on the move. The Dispatch Handler Agent, another software, validates each package at the dispatch areas and informs the Dispatch Officer to confirm its decision. The Dispatch Officer can override Dispatch Handler decisions if needed and directs the confirmed packages to the postal division.

[see page ten



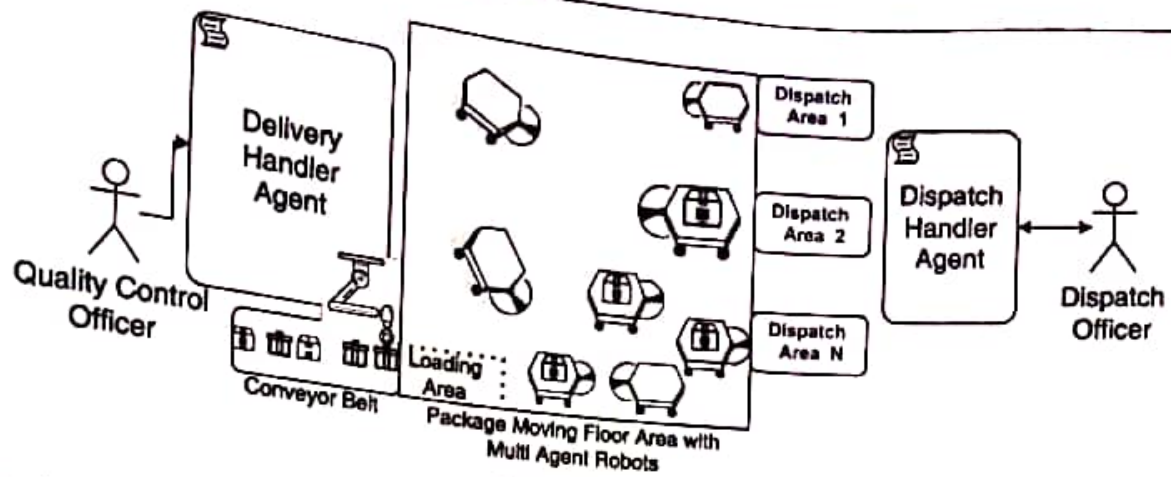


Figure 7.3

- (i) Software Agents demonstrate certain characteristics which make their behaviour unique. Briefly explain the following two characteristics of a software agent:
- autonomous
  - cooperative
- (ii) Name a self-autonomous agent and a user agent in the given example.
- (iii) If the set of multi-agent robots behave satisfying only the autonomous characteristic but fails to cooperate, write down one of the most likely observations that will be seen during their operation.
- (iv) If this system is redesigned by replacing the multi-agent behaviour with centralized control and a broker agent for communication, identify **one** main change that will be seen with respect to each of the following:
- Control of the robot mobility
  - Decision making process (relevant to moving packages from loading area to dispatch areas)
- (v) Draw a *box and arrow diagram* for the new solution with centralized control, mentioned in (iv), above.
- (Note: A box and arrow diagram uses boxes to show system components and arrows to show connections between those components)

8. (a) Write the output of the Python code given in Figure 8.1.

```
def function1(str):
    newstr = ''
    for character in str:
        if character in 'aeiouAEIOU':
            newstr += '*'
        else:
            newstr += character
    return newstr
str1 = "LibrAry"
str2 = function1(str1)
print(str2)
```

Figure 8.1

(b) The function in Figure 8.2 uses the bubblesort algorithm to sort a given list of numbers into ascending order. Write down the suitable replacements for the labels P-U to complete the code.

```
def bubbleSort(nList):
    for pNumber in range(P,Q,R):
        S:
            if nList[i]>nList[i+1]:
                temp = nList[i]
                T
                U
```

Figure 8.2

- (c) An estate owner wants a program to determine the **minimum** currency note combination needed to make the pay of each employee. (E.g., Rs. 40,000 should be paid using eight notes of Rs. 5000 and not four hundred notes of Rs. 100). The program should also output the currency requirement for all employees. The program should use the **employees.txt** file which contains employee pay details. Each line in it contains an employee's name and net pay. A Python program written for this purpose is shown in Figure 8.3. A sample **employees.txt** file and the program's output for that file are shown in Figure 8.4.

- (i) Write down the suitable replacements for the ten labels A-J in the program given in Figure 8.3.

```
# currency notes used in Sri Lanka
notes = [5000,1000,500,100,50,20]
# total notes required from each currency note type
totals = [0,0,0,0,0,0]

file = A('employees.txt','r')

while True:
    required = [0,0,0,0,0,0] # notes required for employee

    line = file.readline()
    if B line:
        C

        empDetails = line.split()
        netpay = int(float(D))
        if netpay < 0:
            continue

        print("\n")
        print(empDetails[0], "Net pay =", netpay)
        topay = netpay
        i = 0
        while topay > 0:
            required[i] = E
            totals[i] = totals[i] + F
            topay = G
            H

        # print employee netpay breakdown
        for i in range(0, len(required)):
            print("Rs.", notes[i], ":", I)
        J

    print("\nTOTAL REQUIREMENT:")
    for i in range(0, len(totals)):
        print("Rs.", notes[i], ":", totals[i])
```

Figure 8.3

Example 'employees.txt' file:

Raj 40120  
Niranjala 51670

Program's output for that file:

Raj Net pay = 40120  
Rs. 5000 : 8  
Rs. 1000 : 0  
Rs. 500 : 0  
Rs. 100 : 1  
Rs. 50 : 0  
Rs. 20 : 1

Niranjala Net pay = 51670  
Rs. 5000 : 10  
Rs. 1000 : 1  
Rs. 500 : 1  
Rs. 100 : 1  
Rs. 50 : 1  
Rs. 20 : 1

TOTAL REQUIREMENT:  
Rs. 5000 : 18  
Rs. 1000 : 1  
Rs. 500 : 1  
Rs. 100 : 2  
Rs. 50 : 1  
Rs. 20 : 2

Figure 8.4

- (ii) The net pay of employees in this estate, does not contain cents. However, what practical problem with respect to the net pay inputs exists in this code? What modifications will you do to fix that problem?



9. (a) Consider the following requirements relevant to a database that is expected to manage divisions, officers and tasks in an office.

The office consists of a number of divisions. Each division has a unique name. The division may have several locations. A division handles a number of tasks each of which has a unique number, a name and a date in which the task was assigned to the division. Each officer's name (consisting of a first name and a surname), NIC (National Identity Card) number, address and phone number is to be stored. An officer is assigned to one division but may work on several tasks which may not be controlled by the same division. Each division is managed by one of its officers and the starting date in which the officer started managing the division is stored. Draw an ER diagram for this application showing the entities, attributes and relationships. Underline primary keys.

- (b) Write two advantages of converting a database table into a normal form.

- (c) Consider the following Show table related to theatres and the movies that they screen.

Theatre	Movie	Day	Time	Screen	Year
Sarasi	MI - 4	Wednesday	10:00	S <sub>1</sub>	2022
Sarasi	MI - 4	Wednesday	15:00	S <sub>1</sub>	2022
Palazzo	Spider man	Friday	10:00	S <sub>2</sub>	2019
Palazzo	Avengers	Friday	10:00	S <sub>1</sub>	2019
Vega	Iron man	Thursday	10:00	S <sub>1</sub>	2020

Note:

- A theatre can screen more than one movie at the same time on different screens.
- Year field gives the year in which the relevant film was released.

- (i) In which normal form does the Show table exist? Justify your answer.

- (ii) Convert the Show table to its next normal form.

- (d) Consider the following Employee table:

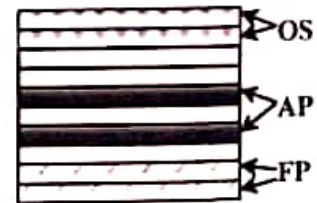
Emp_ID	Emp_Name	DoB	Department	Designation	DoJ	Salary
E110	Saman	15/10/1970	Bio Technology	Professor	12/04/2001	145000
E111	Kumar	25/05/1980	Mechanical	Assistant Professor	02/05/2006	100000
E115	Raja	10/08/1982	Engineering	Assistant Professor	05/05/2001	98000
E114	Jennifer	11/09/1975	Engineering	Assistant Professor	03/06/2001	197000
E117	Ismail	15/05/1979	Civil	Assistant Professor	10/05/2005	103000

- (i) Write the most suitable SQL statement to create the Employee table with a suitable primary key.
- (ii) Write the required SQL statement to insert the record for the following employee:  
Emp\_ID = E119, Emp\_Name = "John", DoB = "15/06/1971", Department = "IT", Designation = "Professor", DoJ = "15/07/2001", Salary = 107000
- (iii) Write the output obtained by applying the following SQL query:  
SELECT Emp\_ID, Emp\_Name  
FROM Employee  
WHERE Salary > 103000;
- (iv) Write the appropriate SQL query to find the names of all employees who work in the "Civil" department.

[see page thirteen]

10. (a) (i) What is the repeating cycle that a processor in a computer is involved in since the computer is started till it is shutdown?
- (ii) Which program's instructions get executed in the processor of a computer during a *context switch*?
- (iii) A *register* is a group of binary cells suitable for holding binary information and is constituted by a collection of flip-flops. How many flip-flops are needed to make an  $n$ -bit register?
- (b) A user runs the following Python codes on a computer. The code on left prints the lines of a file on the screen while the other code does an average computation.

fileReader.py	average.py
A = input("Enter filename")	total = 0
f1 = open(A, "r")	for num in range(10000):
for line in f1:	total += num
print(line)	average = total / 10000
f1.close()	print(average)



Memory  
Figure 10.1

The computer's memory at a particular time is shown in the figure 10.1. The memory frames occupied by the *operating system*, the *fileReader process* and the *average process* are indicated on it by OS, FP and AP respectively.

Selecting from OS, AP and FP, write down the most likely place where each of the following is stored.

- content of variable A of the *fileReader process*
  - the Process Control Block (PCB) of the *average process*
- (c) Of the above two python processes, one of them will go through the RUNNING  $\rightarrow$  BLOCKED state transition more than the other. Which process is that? Give the reason for it.
- (d) Assume that when the *fileReader process* of (b) above is in progress a context switch occurs and a different process is run. When the *fileReader process* is given the chance to run again, the file is read from where it stopped. Which data structure facilitates that feature?
- (e) A computer uses 32-bit virtual addresses. This computer has a 1 GB ( $2^{30}$  bytes) physical memory and a 4 KB page size.
- Write down the number of frames in physical memory as a power of 2.
  - Assume that in addition to memory frame information, each page table entry for a virtual page in this computer contains some additional information consisting of a total of **four bits**. If the total size of the page table required for each process on this computer assuming that all virtual pages are in use is given as  $2^p \times q$  bits, write down the values of  $p$  and  $q$ .
  - If the virtual address 4097 of a particular process is mapped to *Frame 2* of physical memory, write down in **decimal** form, the physical address corresponding to the virtual address 4097. (Assume that page numbers, frame numbers and addresses begin from 0)
- (f) The *test.py* file is stored on blocks 218 and 220 respectively in a disk that uses a File Allocation Table (FAT) to manage its storage. The disk uses 4 KB blocks.
- Write down an important number in the *directory entry* for the *test.py* file that will help the operating system to find the blocks of the file.
  - Give an example size for *test.py* that will result in *internal fragmentation*.
  - Assume that block 219 is also to be added for the *test.py* file. Show in a diagram the FAT entries for the *test.py* file after this addition.  
(-1 indicates last block)

