National University of Computer and Emerging Sciences, Lahore Campus

	Course Name:	Software Quality Engineering	Course Code:	SE 3002
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	Exam Duration:	3 Hours	Total Marks:	140
	Paper Date:	22-Dec-23	Weight	40%
	Section:	All	Page(s):	14
	Exam Type:	Final		

Student : Name:_____ **Roll No.**_____ **Section:**_____

Instruction/Notes:
1. Attempt all questions on the question paper. Do not submit any extra sheet, it will not be graded.
2. You are allowed to use a two-sided, hand-written, A-4 size help sheet. Colored or black & white photocopies are not allowed.
3. State your assumptions clearly

Question 1 (Marks = 1x25=25)

In each of the following MCQs, **circle** the most appropriate **single** option. Unclear answers will not be given any credit. (MCQ 1 to 8 CLO 1, all others CLO 4)

1. _____ is considered an external quality attribute of software
   a. Maintainability
   b. Usability
   c. Defect density
   d. Efficiency
   e. a, b, c only
2. Which process maturity model focuses on continuous improvement of an organization's processes?
   a. CMMI
   b. ISO
   c. Six Sigma
   d. All of the above
   e. None of the mentioned
3. Following maturity level of the CMMI model emphasizes creating and maintaining process discipline
   a. Initial
   b. Managed
   c. Defined
   d. Optimizing
4. Which level of measurement best describes ordinal data in software quality metrics?
   a. Interval
   b. Nominal
   c. Ratio
   d. Ordinal
5. Which of the following is not a fundamental principle of Total Quality Management (TQM)?
   a. Continuous improvement
   b. Customer focus
   c. Employee empowerment
   d. Resource optimization

6. Which of the following is a benefit of conducting inspections as a mechanism for ensuring software quality?
    a. Early detection of defects
    b. Reliable test coverage
    c. Improved user experience
    d. Reduced maintenance effort
    e. a, b, and d only
7. _____focuses on the behavior of the software from an end-user perspective
    a. Black box testing
    b. White box testing
    c. Grey box testing
    d. Ad-hoc testing
8. Inspections in software quality assurance are primarily focused on:
    a. Identifying defects in software code
    b. Executing predefined test cases
    c. Assessing user satisfaction with the software
    d. Reviewing documentation and design artifacts
9. Test case design techniques are primarily concerned with:
    a. Estimating project effort
    b. Reporting software defects
    c. Defining software requirements
    d. Creating effective test cases
10. Mutation testing is a technique used to assess:
    a. Code coverage
    b. Test case effectiveness
    c. System performance
    d. Code quality
    e. b and d only
11. Acceptance testing is conducted to:
    a. Validate the software against user requirements
    b. Ensure compliance with coding standards
    c. Evaluate the system performance under stress conditions
    d. Determine the level of maintenance effort required
12. Continuous Integration (CI) is a process that prescribes to:
    a. Regularly merge code changes into a common repository
    b. Conduct comprehensive end-to-end tests
    c. Automate all manual testing activities
    d. Analyze code complexity and maintainability
    e. a and c only
13. Equivalence class partitioning (ECP) is based on the assumption that:
    a. Some inputs are more important than others
    b. Inputs can be divided into groups that are likely to exhibit similar behavior
    c. All inputs should be tested individually
    d. The most complex inputs should be tested first
14. Which type of software testing technique involves running tests without referring to the internal structures of the software?
    a. White box testing
    b. Grey box testing
    c. Ad-hoc testing
    d. None of the above

15. Which of the following is NOT an objective of system testing?
    a. To ensure that all system components work together as expected
    b. To validate the system against functional and non-functional requirements
    c. To identify defects in individual modules or components
    d. To verify the proper interaction between software and hardware components
16. Which of the following best describes Continuous Integration/Continuous Deployment (CI/CD)?
    a. A process that automatically deploys the latest software version into production
    b. A form of iterative software development that focuses on user feedback
    c. A practice of integrating code changes frequently to detect integration issues early
    d. A strategy for monitoring and improving the performance of a live software system
    e. and c only
17. Which type of software testing assesses the software's ability to recover from failures or interruptions?
    a. Stress testing
    b. Recovery testing
    c. Performance testing
    d. Security testing
18. Which of the following statements about automation testing is/are correct?
    a. It eliminates the need for manual testing entirely.
    b. It speeds up the testing process.
    c. It can be used only for functional testing.
    d. It improves test coverage.
    e. b and d only
19. In an Agile development environment, which of the following test levels are typically performed?
    a. Unit testing
    b. System testing
    c. Acceptance Testing
    d. All of the above
20. Which of the following practices are associated with Agile testing?
    a. Test-driven development (TDD)
    b. Continuous integration
    c. Waterfall methodology
    d. Heavy documentation
    e. a and b only
21. Which of the following statements about continuous integration and continuous deployment (CI/CD) are correct?
    a. CI/CD ensures that developers commit code less frequently.
    b. CI/CD automates the build, test, and deployment processes.
    c. CI/CD helps in identifying integration issues early.
    d. CI/CD fosters collaboration and reduces manual errors.
    e. All of the above
    f. b, c, and d only
22. Which of the following tools or frameworks are commonly used for test automation in Agile development?
    a. Selenium
    b. JUnit
    c. GitHub Actions
    d. All of the above
    e. None of the mentioned

23. In Agile testing, which of the following statements about user stories and acceptance criteria are correct?
    a. User stories describe the user viewpoint of a software feature.
    b. Acceptance criteria define the key requirements for user stories.
    c. User stories replace the need for test cases.
    d. Acceptance criteria serves as the basis for creating test cases.
    e. a, b, d only
24. Which of the following statements about exploratory testing are correct?
    a. It is a structured and scripted approach to testing.
    b. It focuses on discovering defects by dynamic learning.
    c. It replaces the need for test cases.
    d. It is suitable for lengthy and time-consuming testing efforts.
    e. a, b, and d only
25. Which of the following activities are typically included in a continuous testing strategy?
    a. Writing comprehensive test cases upfront
    b. Automating functional and regression testing
    c. Conducting manual exploratory testing
    d. Analyzing test results and monitoring quality metrics
    e. b, c, d only.

Question 2 (Marks = 4x5 = 20) CLO 3

A company, My Development Company (MDC), develops web-based applications. MDC is applying statistical quality control during the testing process and tracking MTBF of the applications.

Different requirements regarding the applications that need to be met are as follows:

1. Search operation should complete within 3 seconds of the request 95% of the time
2. The application should work functionally correct 95% of the time
3. The application should run without failures 90% of the time

MDC tested the current version of an application for two weeks (i.e. 10 days) and removed the defects during these 10 days. The defects correction resulted in change in size of the application (measured in terms of Source Lines of Code or SLOC). The number of defects captured every day and the number of failures encountered every day are also recorded. The company has the following raw data collected during the testing phase:

Time (Day)	SLOC	Defects	Failures
1	1705	62	7
2	1798	66	8
3	1776	96	13
4	1843	78	17
5	1925	66	15
6	1890	45	11
7	1875	50	19
8	2000	40	14
9	2080	55	8
10	2000	52	10

After the 10 days period MDC needs to determine if the application is stable in terms of failures or not. They'll decide whether they should go with further testing if the number of failures is not within the limits. They'd like to do it with the help of the control charts.

a. Draw the control chart for the number of failures and give conclusions that help MDC. Label the control chart clearly. The labeling should be complete. **Hint:** UCL, LCL, Average etc. might help reach a decision.

b. Given the above table, find DRE of the first week when total number of defects fixed the first week is 340. Show all steps.

DRE = Defects removed/Defects Latent x 100

Defects Latent = 340 + (610-368) = 340 + 242 = 582

DRE = 340/582 x 100

DRE = 58.4 %

c. Suppose MDC opts to stop testing and the application goes into production. Post release defects reported in one week in production is 300, total number of defects fixed in the two weeks of testing is 590. Find DRE of the testing phase. Show all steps.

DRE = Defects removed/Defects Latent x 100

Defects Latent = 590 + 300 = 890

DRE = 590/890 x 100

DRE = 66.2 %

d. Which of the DRE values calculated in part b and c is better? Why? Give reason(s)

DRE of part c is better, higher the value of DRE the better it is

Question 3 (Marks = 2 + 15 + 3 = 20) CLO 4

Consider the NextDate Function discussed in class. There is a similar function with name PreviousDate which takes three parameters month, date, and year, all as integer values and subject to the following conditions:

$1 \le month \le 12$, $1 \le day \le 31$, $1712 \le year \le 2112$

Set of equivalence classes for these variables are given below:

M1 = {month: month has 31 days, month is not in {M4, M5}, previous month is NOT in M1}
M2 = {month: month has 31 days, month is not in {M4, M5}, previous month is in M1}
M3 = {month: month is February} M4 = {month: month is January}
M5 = {month: month is March} D1 = {day: day = 1} D2 = { day: $2 \le day \le 28$}
D3 = {day: day = 29} D4 = {day: day = 30} D5 = {day: day = 31}
Y1 = {year: year is a leap year} Y2 = {year: year is not a leap year}

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
c1: month in	M1	M1	M1	M1	M1	M2	M2	M2	M2	M2	M3	M3	M3	M3	M3
c2: day in	D1	D2	D3	D4	D5	D1	D2	D3	D4	D5	D1	D2	D2	D3	D3
c3: year in	-	-	-	-	-	-	-	-	-	-	-	Y1	Y2	Y1	Y2
Action															
a1: Impossible															x
a2: decrement day		x	x	x	x		x	x	x	x		X	x	x	
a3: decrement month	x					x					x				
a4: decrement year															
a5: set month to December															
a6: set day to 31						x					x				
a7: set day to 30	x														
a8: set day to 29															
a9: set day to 28															

	16	17	18	19	20	21	22	23	24	25	26	27	28
c1: month in	M3	M3	M4	M4	M4	M4	M5	M5	M5	M5	M5	M5	M5
c2: day in	D4	D5	D1	D2	D3	D4	D5	D1	D1	D2	D3	D4	D5
c3: year in	-	-	-	-	-	-	-	Y1	Y2	-	-	-	-
Action													
a1: Impossible	x	x											
a2: decrement day				x	x	x	X			x	×	×	×
a3: decrement month								x	x				
a4: decrement year			x										
a5: set month to December			x										
a6: set day to 31			x										
a7: set day to 30													
a8: set day to 29								x					
a9: set day to 28									x				

To do:

a. Complete the decision table by filling the two highlighted columns (rule 12 and 22).
b. Provide test cases for rules 1, 2, 5, 6, 11, 12, 15, 16, 18, 19, 20, 22, 23, 24, 25 using an appropriate structure.

For Question 3

Sr.	Purpose	Input(M,D,Y)	Expected Output (M,D,Y)
1	Test for Rule 1:	5 1 2023	4 30 2023
2	Test for Rule 2:	5 2 2023	5 1 2023
3	Test for Rule 5:	5 31 2023	5 30 2023
4	Test for Rule 6:	8 1 2023	7 31 2023
5	Test for Rule 11:	2 1 2023	1 31 2023
6	Test for Rule 12:	2 28 2020	2 27 2020
7	Test for Rule 15:	Impossible	
8	Test for Rule 16:	Impossible	
9	Test for Rule 18 :	1 1 2024	12 31 2023
10	Test for Rule 19 :	1 28 2024	1 27 2024
11	Test for Rule 20 :	1 29 2024	1 28 2024
12	Test for Rule 22 :	3 31 2024	3 30 2024
13	Test for Rule 23 :	3 1 2024	2 29 2024
14	Test for Rule 24 :	3 1 2023	2 28 2023
15	Test for Rule 25 :	3 25 2023	3 24 2023

Question 4 (Marks = 4x5=20) CLO 4

LESCO has installed electricity meters (for domestic use) with the ability to record peak hour usage and off-peak hour usage of electricity. Electricity rate is low during off peak hours. LESCO provides details of the peak hours in years 2015 and 2016 as below:

a. March 1 to May 30 — 10 PM to 6 PM (next day)
b. May 31 to August 31 — 11 PM to 7 PM (next day)
c. September 1 to November 30 — 10 PM to 6 PM (next day)
d. December 1 to February 29 — 9 PM to 5 PM (next day)

The meters have **embedded software** that keeps count of the units using a local clock. A unit consumed at 6 PM in 'case a' will be considered a unit consumed in peak hours. Electricity rate for the 4 cases above are as follows:

a. PKR 7 per unit in off-peak hours and PKR 9 per unit in peak hours.
b. PKR 8 per unit in off-peak hours and PKR 10 per unit in peak hours.
c. PKR 6.5 per unit in off-peak hours and PKR 8.5 per unit in peak hours.
d. PKR 6 per unit in off-peak hours and PKR 8.5 per unit in peak hours.

Meter readers send the number of units consumed in peak and off-peak hours to LESCO office where a Desk Clerk enters the data in the computerized **billing system** through a graphical user interface and asks the system to generate bill. The computerized system at LESCO also performs bill related calculations using the above information. The generated bill shows the units consumed and the total price of the electricity. Assume that there is 10% tax on total price of electricity. Assume that there is no additional surcharge if late payment is made.

To do:

a. Design equivalence classes for the testing of the embedded software.

There can be other solutions i.e. equivalence classes different from the following, one solution is as follows:
Two variables are Day and Time of consumption

ECs for Day:
EC 1: March 1 <= Day <= May 30
EC 2: May 31 <= Day <= August 31
EC 3: September 1 <= Day <= November 30
EC 4: December 1 <= Day <= February 29

EC 5: 5PM < Time <= 6 PM
EC 6: 6PM < Time <= 7 PM
EC 7: 7PM < Time <= 9 PM
EC 8: 9PM <= Time < 10 PM
EC 9: 10PM <= Time < 11 PM
EC 10: 11PM <= Time < 12AM
EC 11: 12AM <= Time < 5PM

b. To test the embedded software, design the test cases using the on boundary values and write the test cases using an appropriate test structure.

Sr.	Purpose	Input	EO
1	Test with the lower on-boundary value of EC 1 and peak hours	March 1, 10 PM	Peak hour
2	Test with the upper on-boundary value of EC 1 and peak hours	May 30, 6 PM	Peak hour
3	Test with the lower on-boundary value of EC 2 and peak hours	May 31, 11 PM	Peak hour
4	Test with the upper on-boundary value of EC 2 and peak hours	August 31, 7 PM	Peak hour
5	Test with the lower on-boundary value of EC 3 and peak hours	September 1, 10 PM	Peak hour
6	Test with the upper on-boundary value of EC 3 and peak hours	November 30, 6 PM	Peak hour
7	Test with the lower on-boundary value of EC 4 and peak hours	December 1, 9 PM	Peak hour
8	Test with the upper on-boundary value of EC 4 and peak hours	February 29, 5 PM	Peak hour
9	On boundary value of EC 6	March 30, 7 PM	Off-peak
10	On boundary value of EC 10	April 10, 12 AM	Peak hour
11	On boundary value of EC 11	February 10, 10 AM	Peak hour

c. Design equivalence classes for the testing of the billing system

Four valid equivalence classes (EC 1 to 4) for input units consumed in off-peak hours in four cases a, b, c, d
Four valid equivalence classes (EC 5 to 8) for input units consumed in peak hours in four cases a, b, c, d
There can be invalid classes for units e.g. –ve values, non integer values etc.

d. Design equivalence class based test cases to test if the LESCO billing system counts the units correctly and calculates the total payable bill correctly.

Sr.	Purpose	Input	Units, Price of electricity, Bill
1	Test for EC 1	100 units off peak hours in case a	100, 700, 770
2	Test for EC 5	100 units peak hours in case a	100, 900, 990
3	Test for EC 2	100 units off peak hours in case b	100, 800, 880
4	Test for EC 6	100 units peak hours in case b	100, 1000, 1100
5	Test for EC 3	100 units off peak hours in case c	100, 650, 715
6	Test for EC 7	100 units peak hours in case c	100, 850, 935
7	Test for EC 4	100 units off peak hours in case d	100, 600, 660
8	Test for EC 8	100 units peak hours in case d	100, 850, 935
9	Test for Invalid EC	r45 units	Invalid units

Question 5 (Marks = 3+2+2+9+3 = 20) CLO 4

A bank has created a new data processing system that is ready for testing. This bank has different kinds of customers—consumers, very important consumers, businesses, and non-profits; different kinds of accounts—checking, savings, mortgages, consumer loans, and commercial loans; they operate in different states, each with different regulations—California, Nevada, Utah, Idaho, and Arizona. Perform pairwise testing of the data processing system and solve the following:

a. Name the variables from this scenario

b. Determine the number of choices for each variable

c. Considering the given scenario, identify the number of columns and maximum values in each column for a suitable orthogonal array with 25 rows. Give a mapping for each variable also.

d. A few entries from a closest matching orthogonal array are shown below. Map the test problem onto the subset of the orthogonal array and fill it with appropriate values. Show how to handle the left-overs appropriately.

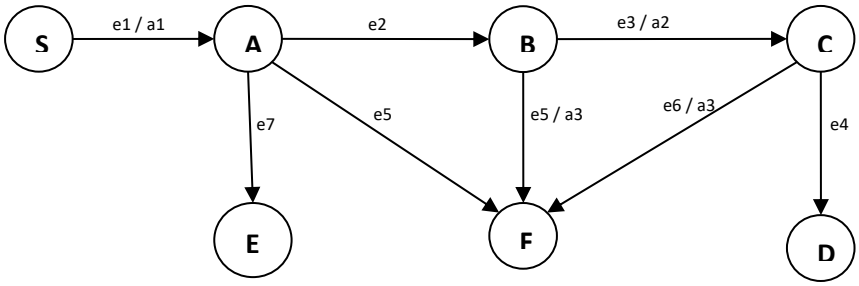
111111	consumers	Checking	California			
122345	consumers	Saving	Nevada			
133452	consumers	Mortgage	Utah			
144523	consumers	Cons loans	Idaho			
155234	consumers	Com loans	Arizona			
235143	VIC	Mortgage	Arizona			
334215	Businesses	Mortgage	Idaho			
453125	non-profits	Com loans	Utah			
524132	consumers	Saving	Idaho			

e. How to develop test cases now?

Add an expected behavior column in the table given in part d

Question 6 (Marks = 10) CLO 4

Consider the following state transition diagram:



Create a set of minimum test cases to achieve the following coverages (only write the sequence in which states are visited e.g. S, A, B, C, D):

a. All states are visited atleast once

- S, A, E
- S, A, B, F
- S, A, B, C, D

b. All events are triggered atleast once

- S, A, E
- S, A, B, F OR S, A, F
- S, A, B, C, D
- S, A, B, C, F

c. All transitions are exercised atleast once

- S, A, E
- S, A, F
- S, A, B, F
- S, A, B, C, D
- S, A, B, C, F

Question 7 (Marks = 7x3=21) CLO 4

Answer the following questions briefly. Try not to use more than 3 sentences in each part.

a. What is the difference between quality control and quality assurance?

b. How does Agile Testing improve the quality of software product and process of the team?

c. How does CI/CD help with achieving a High quality of Product?

d. List 3 key points to remember when selecting a tool for Automated Testing?

e. List 3 Benefits of Automated Testing?

f. What is the difference between Regression Testing and Retesting?

g. What differentiates Exploratory Testing from Ad-Hoc testing?

Question 8 (Marks = 4) CLO 1

Mention the metrics used to measure the following:

Performance: Response time, Speed index, Throughput, TPS

Reliability: MTTR, MTBF

Usability: User satisfaction, Learnability, Task completion time

Customer Satisfaction: Net promoter score, Surveys,