Student ID (*Matricola*)

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6	6	6	6	6	6
7	7	7	7	7	7
8	8	8	8	8	8
9	9	9	9	9	9

Computing Infrastructures

Course 095897

P. Cremonesi, M. Roveri

Example exam

Last Name / Cognome:

. . . .

First Name / Nome:

. . . .

Answers must be given exclusively on the answer sheet (last sheet): DO NOT FILL ANY BOX IN THIS SHEET

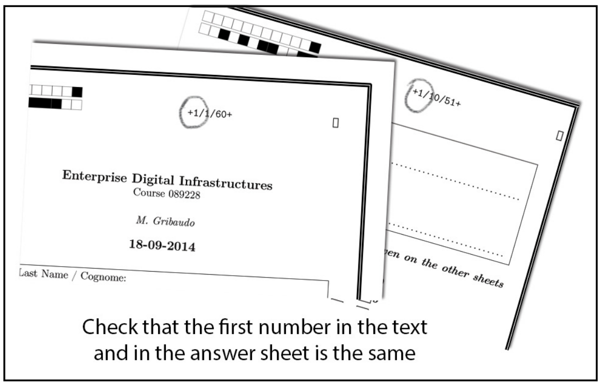
Students must use pen (black or blue) to mark answers (no pencil).
Students are permitted to use a non-programmable calculator.

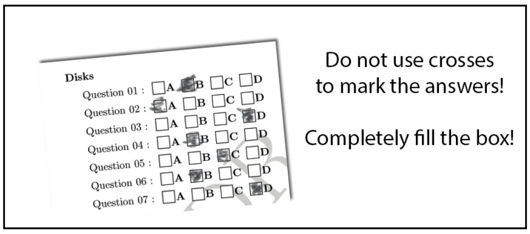
Students are NOT permitted to copy anyone else's answers, pass notes amongst themselves, or engage in other forms of misconduct at any time during the exam.

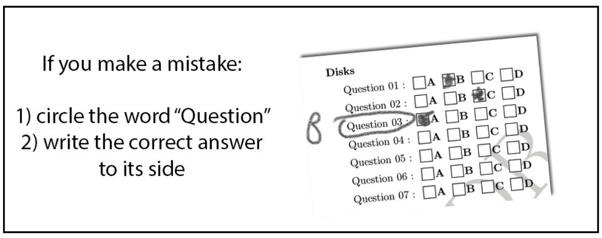
Students are NOT permitted to use mobile phones and similar connected devices.

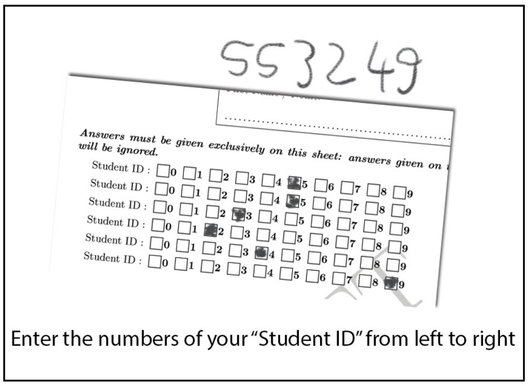
Scores: correct answers +1.5 point, unanswered questions 0 points, wrong answers -0.5 points.

Questions will multiple answers will be considered as not answered (0 points).









Question 1 The User ISA encompasses:

[A] The aspects of the ISA that are visible to the application program and operating system

[B] The aspects of the ISA that are visible to the operating system and software libraries

[C] The aspects of the ISA that allow to interact with the hardware for drivers, memory management and scheduling

■ The aspects of the ISA that are visible to the application program

Question 2 One of these configurations is not considered in Data-center network architectures. Which one?

[A] Fat-tree

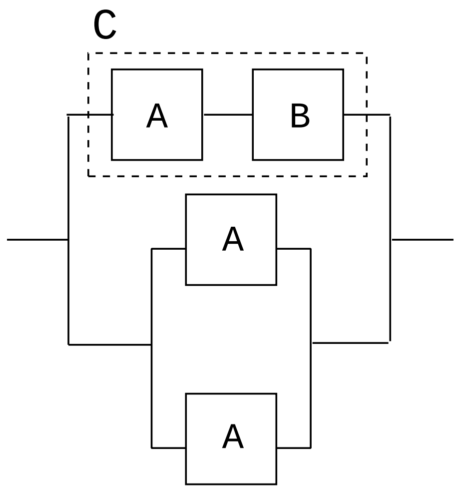
[B] D-Cell

■ Direct Connection

[D] Three layers

In the following questions we will assume that both failure and repair events follow exponential distributions.

Question 3
Consider now the components A and B organized as in figure below. Assume for component A: $MTTF_A = 226\ days$ and $MTTR_A = 1\ days$ and for component B: $MTTF_B = 482\ days$ and $MTTR_B = 5\ days$.



The MTTF without repair of block C is equal to:

[A] 354.00000 [B] 131.26234 [C] 39.62195 ■ 153.85876

Explanation: $MTTF_C = 1/(1/MTTF_A + 1/MTTF_B)$

Question 4

Consider a system built by two different components in parallel. Assume for component A: $MTTF_A = 167\ days$ and $MTTR_A = 1\ days$ and for component B: $MTTF_B = 444\ days$ and $MTTR_B = 5\ days$.

The reliability of the system at $t = 8\ days$ is equal to:

[A] 0.986992 [B] 0.982143 ■ 0.999165 [D] 0.983794

Explanation: $R_A(t) = e^{-t/MTTF_a}$ $R_B(t) = e^{-t/MTTF_b}$ $R_{sys}(t) = 1 - (1 - R_A(t)) * (1 - R_B(t))$

Question 5

Consider a system built by two different components in parallel. Assume for component A: $MTTF_A = 186\ days$ and $MTTR_A = 8\ days$ and for component B: $MTTF_B = 262\ days$ and $MTTR_B = 13\ days$. The availability of the whole system is equal to:

[A] 0.955745 [B] None of the others [C] 0.913439 ■ 0.998051

Explanation: $A_A = MTTF_A/(MTTF_A + MTTR_A) = 0.95876$
$A_B = MTTF_B/(MTTF_B + MTTR_B) = 0.95273$
$A_{sys} = 1 - (1 - A_A) * (1 - A_B) = 0.998051$

Question 6 The Nested Pages mechanism:

■ is supported by the Translation Lookaside Buffer (TLB)
[B] does not require special hardware to support it
[C] implies more software-level overhead than the Shadow Pages mechanism
[D] is completely managed by the VMM software

Explanation: Lesson_3_Virtualization_B.pdf, slide 31

Question 7 In memory virtualization, "ballooning" is a technique that:

- [A] implies that the VMM determines the pages that are less used
- [B] separates user logical memory from physical memory
- [■] allows the VMM to ask guest VMs to release memory pages
- [D] does not require support from the Guest OS

Explanation: Lesson_3_Virtualization_B.pdf, slide 18

Question 8 A system is composed by 2 physical machines (Host1, Host2), with subnet addresses: 192.168.0.1 and 192.168.0.2 (default subnet mask: 255.255.255.0). Two Virtual Machines, VM1 and VM2 run over Host1, connected in NAT mode. Other two Virtual Machines, VM3 and VM4 run over Host2, connected in bridged mode. Assuming that port-forwarding is configured to map port X of the guest on the same port X on the host:

- [A] VM3 and VM4 are not reachable by Host1
- [B] a service running inside VM3 and listening on port 22 can be reached at the address: 192.168.0.2:22
- [■] a service running inside VM2 and listening on port 8080 can be reached at the address: 192.168.0.1:8080
- [D] 192.168.0.3 is a possible IP address for VM1 on the hosts' subnet

Explanation: No port-forwarding is required for VM3 and VM4, as they have IP addresses on the same subnet: 192.168.0.Y, reachable from Host1. Moreover, VM1 is NATted, so a service it hosts on port X can be reached at: 192.168.0.1:X

Question 9
Consider a HDD with:

- data transfer rate: 280 MB/s
- rotation speed: 12000 RPM
- mean seek time: 16 ms
- overhead controller: 0.8 ms

The mean I/O service time to transfer a sector of 5 KB will be:

[A] 2.51 ms ■ 19.32 ms [C] 1.36 ms [D] 0.94 ms

Explanation: Mean latency: (1/2 round) * (60s/min) * 1/(12000 round/min) = 2.499 ms
Transfer time: (5 KB) / (280 * 1024 KB/s) = 0.017ms
Mean I/O service time = 16 + 0.8 + 2.499 + 0.017 = 19.32

Question 10
Consider the following RAID 6 setup:

- n = 5 disks
- MTTR = 3 days
- MTTF(one disk) = 1000 day

The MTTDL will be:

[A] 27777778 days [B] 11111 days ■ 3703704 days [D] none of the others

Explanation: $MTTDL = 2 * MTTF^3/(n * (n-1) * (n-2) * MTTR^2) = 3703704 days$

Question 11
Consider 3 groups (RAID 0) of 2 disks each (RAID 1), for a total of 6 disks in configuration RAID 1+0:

- MTTR = 3 days
- MTTF(one disk) = 1600 day

The MTTDL will be:

[A] 455111111 days ■ 142222 days [C] 682666667 days [D] none of the others

Explanation: $MTTDL = MTTF^2/(totaldisks * MTTR)$ = 142222 days (MTTDL is the same for any couple of disks (data and mirror) of the array)

Question 12
Consider a single-class multi station system with two stations. We have the following information about the system:

- station 1 response time: 8 seconds
- station 2 response time: 2 seconds
- station 1 throughput: 4 transactions/second
- station 2 throughput: 6 transactions/second
- system throughput: 4 transactions/second

Which is the average response time of the system?

[A] 0.63 sec [B] 7.63 sec ■ 11.00 sec [D] 10.00 sec

Explanation: V1 = X1 / X
V2 = X2 / X
R1 = r1 V1
R2 = r2 V2
R = R1 + R2

Question 13
Consider the following measurement data for an interactive system

- measurement interval: 4 minutes
- number of users: 48
- number of servers: 22
- average response time per transaction: 17 seconds
- Dmax 2.4 sec/transaction
- Dtot 2.5 sec/transaction
- number of completed transactions: 79

On average, how many users are thinking?

A 14.43	■ 42.40	C 5.60	D 32.95

Explanation: Nthink = N - Nnot-think
Nnot-think = X R
X = C / T

Question 14
Consider a closed system with the following data: average number of users: 23 ($N = 23$) average response time: 28 sec ($R = 28$), average throughput: 0.49 trans/sec ($X = 0.49$), average CPU service demand: 0.60 sec/trans ($D_{\text{CPU}} = 0.60$). Which is the average think time Z of a user?

A 46.94 sec	B 38.33 sec	■ 18.94 sec	D 10.33 sec

Explanation: Z = N/X - R

Question 15
By monitoring a single class iteractive system, we are able to measure the following data:

- Monitoring period: 4 minutes
- Disk utilization: 0.30
- CPU utilization: 0.63
- CPU demand: 0.44 seconds/transaction
- Number of I/O operations / transaction 10
- Response time: 18 seconds/transaction
- Number of users: 42

Which is the average think time of these users?

[A] 29.33 sec ■ 11.33 sec [C] 6.61 sec [D] 9.06 sec

Explanation: Z = N/X - R
X = Ucpu / Dcpu

Question 16
Consider a closed system with the following data: average number of users: 19 ($N = 19$) average response time: 40 sec ($R = 40$), average throughput: 0.48 trans/sec ($X = 0.48$), average CPU service demand: 0.82 sec/trans ($D_{\text{CPU}} = 0.82$). Which is the CPU utilization?

[A] 0.03 [B] 0.47 ■ 0.39 [D] 0.61

Explanation: Ucpu = X*Dcpu

Question 17
Consider a closed queuing network with the following characteristics:

- number of stations K = 3
- service demand Dmax = 1.9
- service demand Dtot = 2.8
- think time Z = 1
- number of users N = 5

Which is the asymptotic upper bound of response time?

[A] 12.54 sec [B] 8.50 sec [C] 10.37 sec [■] 14.00 sec

Explanation: $ND = 5 \times 2.8 = 14.00$

Question 18
Consider a closed queuing network with the following characteristics:

- number of stations K = 1
- service demand Dmax = 1
- service demand Dtot = 1
- think time Z = 2
- number of users N = 4

Which is the asymptotic upper bound of throughput?

[A] 0.667 tran/sec [■] 1 tran/sec [C] 2 tran/sec [D] 0.8 tran/sec

Explanation: $\min(\frac{N}{D+Z}, \frac{1}{D_{max}}) = \min(\frac{3}{2.6+3}, \frac{1}{0.6}) = 0.54$

Question 19
Consider a closed queuing network with the following characteristics:

- number of stations K = 2
- service demand Dmax = 1.2
- service demand Dtot = 2.6
- think time Z = 3
- number of users N = 5

Which is the asymptotic lower bound of throughput?

[A] 0.38 tran/sec ■ 0.31 tran/sec [C] 0.83 tran/sec [D] 0.20 tran/sec

Explanation: $\frac{N}{ND+Z} = \frac{5}{5\times2.6+3} = 0.31$

Question 20
Consider a closed queuing network with the following characteristics:

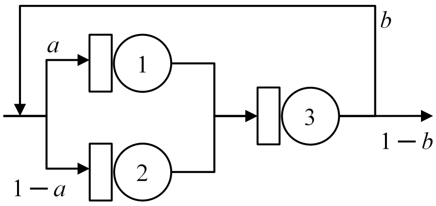
- number of stations K = 1
- service demand Dmax = 1.5
- service demand Dtot = 2.1
- think time Z = 3
- number of users N = 3

Which is the asymptotic lower bound of response time?

[A] 1.64 sec ■ 2.10 sec [C] 1.48 sec [D] 1.06 sec

Explanation: $\max(D, ND_{max} - Z) = \max(2.1, 3 \times 1.5 - 3) = 2.10$

Question 21 Consider the following open network, where a and b are routing probabilities. Which is the number of visits at station 3?



■ $1/(1-b)$ [B] $a+ab$ [C] $(1-a)/(1-b)$ [D] $a/(1-b)$

Explanation: V1 = a*(1 + b*V3)
V2 = (1 - a)*(1 + b*V3)
V3 = V1 + V2 = 1 + b*V3
V3 = 1/(1 - b)
V1 = a/(1 - b)
V2 = (1 - a)/(1 - b)

Question 22
Consider a single-class open queuing network with the following characteristics:

- Visits station A (Va): 1.0
- Visits station B (Vb): 0.8
- Service time station A (Sa): 0.13 sec/tran
- Service time station B (Sb): 0.89 sec/tran
- Arrival rate (λ): 1.19 tran/sec

The system response time $R(\lambda)$ is:

[A] 0.840 sec/tran ■ 4.886 sec/tran [C] 6.086 sec/tran [D] 5.843 sec/tran

Explanation: $R(\lambda) = \frac{D_a}{1-U_a} + \frac{D_b}{1-U_b} = \frac{S_a V_a}{1-\lambda S_a V_a} + \frac{S_b V_b}{1-\lambda S_b V_b} = \frac{0.13\times1.0}{1-1.19\times0.13\times1.0} + \frac{0.89\times0.8}{1-1.19\times0.89\times0.8} =$ 4.886

Answer sheet:

Last Name / Cognome:
....
First Name / Nome:
....

Answers must be given exclusively on this sheet: answers given on the other sheets will be ignored.

Student ID : ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9

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Questions

Question 01 : ☐A ☐B ☐C ■D

Question 02 : ☐A ☐B ■C ☐D

Question 03 : ☐A ☐B ☐C ■D

Question 04 : ☐A ☐B ■C ☐D

Question 05 : ☐A ☐B ☐C ■D

Question 06 : ■A ☐B ☐C ☐D

Question 07 : ☐A ☐B ■C ☐D

Question 08 : ☐A ☐B ■C ☐D

Question 09 : ☐A ■B ☐C ☐D

Question 10 : ☐A ☐B ■C ☐D

Question 11 : ☐A ■B ☐C ☐D

Question 12 : ☐A ☐B ■C ☐D

Question 13 : ☐A ■B ☐C ☐D

Question 14 : ☐A ☐B ■C ☐D

Question 15 : ☐A ■B ☐C ☐D

Question 16 : ☐A ☐B ■C ☐D

Question 17 : ☐A ☐B ☐C ■D

Question 18 : ☐A ■B ☐C ☐D

Question 19 : ☐A ■B ☐C ☐D

Question 20 : ☐A ■B ☐C ☐D

Question 21 : ■A ☐B ☐C ☐D

Question 22 : ☐A ■B ☐C ☐D