Student ID (*Matricola*)

0	0	0	0	0	0
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
5	5	5	5	5	5
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

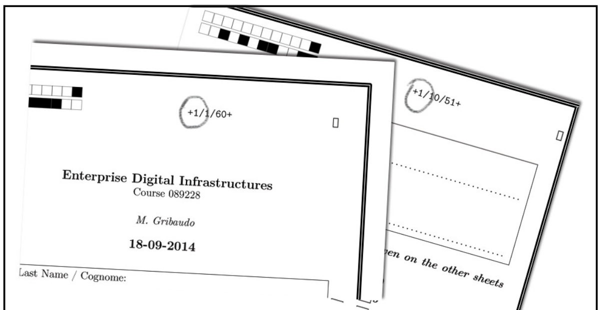
Students must use pen (black or blue) to mark answers (no pencil).
Students are permitted to use a non-programmable calculator.

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.

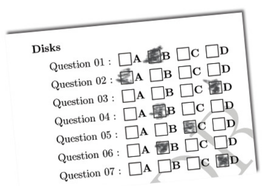
Students are NOT permitted to use mobile phones and similar connected devices.

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).



Check that the first number in the text and in the answer sheet is the same

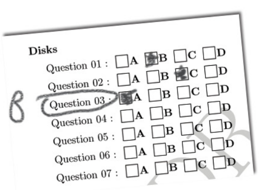


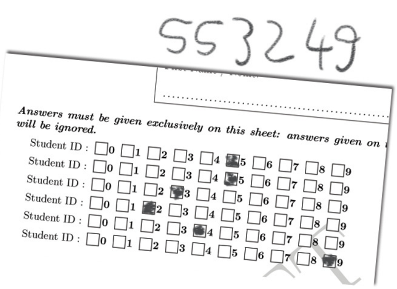
Do not use crosses to mark the answers!

Completely fill the box!

If you make a mistake:

1) circle the word "Question"
2) write the correct answer to its side





Enter the numbers of your "Student ID" from left to right

Question 1 Which module is not typically present in the racks of a DataCenter?

- [A] Servers
- [B] Storage units
- [C] Power distribution units
- ■ Embedded systems

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

- [A] D-Cell
- [B] Fat-tree
- ■ Direct Connection
- [D] Three layers

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

Question 3
Consider a system built by two different components in parallel. Assume for component A: $MTTF_A = 121\ days$ and $MTTR_A = 9\ days$ and for component B: $MTTF_B = 282\ days$ and $MTTR_B = 12\ days$. The availability of the whole system is equal to:

- ■ 0.997174
- [B] 0.892775
- [C] None of the others
- [D] 0.944975

Explanation: $A_A = MTTF_A/(MTTF_A + MTTR_A) = 0.93077$
$A_B = MTTF_B/(MTTF_B + MTTR_B) = 0.95918$
$A_{sys} = 1 - (1 - A_A) * (1 - A_B) = 0.997174$

Question 4
Consider a system built by two different components in parallel. Assume for component A: $MTTF_A = 170\ days$ and $MTTR_A = 1\ days$ and for component B: $MTTF_B = 425\ days$ and $MTTR_B = 5\ days$.
The $MTTF$ computed without repair of the previous system is equal to:

- ■ 473.57143
- [B] 425.00000
- [C] 170.00000
- [D] 72128.57143

Explanation: $MTTF_{sys} = MTTF_A + MTTF_B - 1/(1/MTTF_A + 1/MTTF_B)$

Question 5
Let us now consider a generic component D. Compute the minimum integer value of $MTTF_D$ in order to have at $t = 5$ *days* a reliability $R_D(t) \geq 0.96$.

[A] 97 [B] 5 [C] 7 ■ 123

Explanation: $R_D(t) \geq 0.96$ $\quad e^{-t/MTTF_D} \geq 0.96$ $\quad -t/MTTF_D \geq ln(0.96)$
$MTTF_D \geq -t/ln(0.96)$

Question 6 In memory virtualization, "ballooning" is a technique that:

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

Explanation: Lesson_3_Virtualization_B.pdf, slide 18

Question 7 Consider 4 Virtual Machines (VMs) on 3 different Physical Machines (Hosts):

- Host1 @ 192.168.0.1 runs VM1 and VM2, attached to its NAT adapter;
- Host2 @ 10.0.0.1 run VM3, attached to the Bridge adapter;
- Host3 @ 192.168.0.2 runs VM4, attached to its NAT adapter.

Assuming that the network connecting all the hosts is configured to enable them to see each others (i.e.: Host1 can see Host2):

[A] a service on VM1 can reach a service on VM2 even without port-forwarding, as they are on the same host

■ 10.0.0.4 is a possible IP address for VM3

[C] port-forwarding needs to be configured to expose services running on VM3

[D] none of the other answers is valid

Explanation: A service on VM1 can reach a service on VM2 only if port-forwarding is configured, even if they're on the same host, as they aren't on the same subnet. Moreover, VM4 is NATted, so a service it hosts on port X can be reached at: 192.168.0.2:X, while VM3 will have an IP address on the same subnet: 10.0.0.Y

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] a service running inside VM3 and listening on port 22 can be reached at the address: 192.168.0.2:22

[B] VM3 and VM4 are not reachable by Host1

■ 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:

- block size: 3 KB
- mean I/O service time per block (with no locality): 9.0 ms
- transfer time of 1 block: 0.09 ms
- overhead controller: 0.8 ms

How long does it take to transfer a file of 50 MB if we assume a locality of: 70%?

■ 56.71 s   [B] none of the others   [C] 153.60 s   [D] 61.27 s

Explanation: Total number of blocks to be transferred: 50*1024KB/(3 KB/block) = 17067 blocks
17067*(1-0.70)*9.0ms + 17067*(0.70)*(0.8ms+0.09ms) = 56.71 s

Question 10
Consider the following RAID 5 setup:

- n = 4 disks
- MTTR = 3 days
- MTTF(one disk) = 1000 day

The MTTDL will be:

[A] 28 days   [B] 20833 days   ■ 27778 days   [D] none of the others

Explanation: $MTTDL = MTTF^2/(n*(n-1)*MTTR) = 27778 days$

Question 11
Consider the following RAID 6 setup:

- n = 5 disks
- MTTR = 2 days
- MTTF(one disk) = 1100 day

The MTTDL will be:

[A] 55458333 days ■ 11091667 days [C] none of the others [D] 20167 days

Explanation: $MTTDL = 2 * MTTF^3/(n * (n-1) * (n-2) * MTTR^2) = 11091667 days$

Question 12
By monitoring a single class iteractive system, we are able to measure the following data:

- Monitoring period: 5 minutes
- Disk utilization: 0.26
- CPU utilization: 0.55
- CPU demand: 0.37 seconds/transaction
- Number of I/O operations / transaction 11
- Response time: 17 seconds/transaction
- Number of users: 43

Which is the average think time of these users?

■ 11.93 sec [B] 9.89 sec [C] 7.24 sec [D] 28.93 sec

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

Question 13
Consider a single-class multi station system with two stations. We have the following information about the system:

- station 1 response time: 11 seconds
- station 2 response time: 3 seconds
- station 1 throughput: 4 transactions/second
- station 2 throughput: 5 transactions/second
- system throughput: 4 transactions/second

Which is the average response time of the system?

A 10.90 sec   ■ 14.75 sec   C 0.56 sec   D 14.00 sec

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

Question 14
Consider a closed system with the following data: average number of users: 17 ($N = 17$) average response time: 41 sec ($R = 41$), average throughput: 0.48 trans/sec ($X = 0.48$), average CPU service demand: 0.76 sec/trans ($D_{\text{CPU}} = 0.76$). Which is the CPU utilization?

A 0.57   ■ 0.36   C 0.64   D 0.03

Explanation: Ucpu = X*Dcpu

Question 15

Consider the following measurement data for an interactive system

- measurement interval: 4 minutes
- number of users: 51
- number of servers: 18
- average response time per transaction: 18 seconds
- Dmax 1.9 sec/transaction
- Dtot 2.1 sec/transaction
- number of completed transactions: 72

On average, how many users are thinking?

☐ A 37.85 ☐ B 5.40 ☐ C 18.60 ■ 45.60

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

Question 16

Consider a closed system with the following data: average number of users: 24 ($N = 24$) average response time: 27 sec ($R = 27$), average throughput: 0.47 trans/sec ($X = 0.47$), average CPU service demand: 0.60 sec/trans ($D_{\text{CPU}} = 0.60$). Which is the average think time Z of a user?

☐ A 51.06 sec ☐ B 13.00 sec ■ 24.06 sec ☐ D 40.00 sec

Explanation: Z = N/X - R

Question 17
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 2 tran/sec   B 0.667 tran/sec   ■ 1 tran/sec   D 0.8 tran/sec

Explanation: $\min(\frac{N}{D+Z}, \frac{1}{D_{max}}) = \min(\frac{5}{2.6+3}, \frac{1}{1.9}) = 0.53$

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

- number of stations K = 4
- service demand Dmax = 1.3
- service demand Dtot = 3.2
- think time Z = 2
- number of users N = 3

Which is the asymptotic lower bound of throughput?

A 0.31 tran/sec   ■ 0.26 tran/sec   C 0.77 tran/sec   D 0.18 tran/sec

Explanation: $\frac{N}{ND+Z} = \frac{3}{3\times3.2+2} = 0.26$

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

- number of stations K = 1
- service demand Dmax = 1.2
- service demand Dtot = 1.8
- think time Z = 3
- number of users N = 3

Which is the asymptotic lower bound of response time?

A 0.96 sec | B 0.98 sec | ■ 1.80 sec | D 0.91 sec

Explanation: $\max(D, ND_{max} - Z) = \max(1.8, 3 \times 1.2 - 3) = 1.80$

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

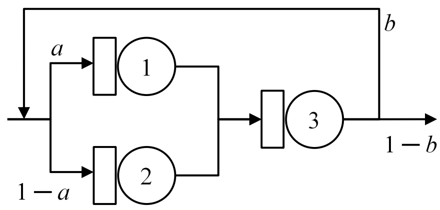
- number of stations K = 2
- service demand Dmax = 0.7
- service demand Dtot = 1.2
- think time Z = 1
- number of users N = 4

Which is the asymptotic upper bound of response time?

■ 4.80 sec | B 3.95 sec | C 3.53 sec | D 1.80 sec

Explanation: $ND = 4 \times 1.2 = 4.80$

Question 21 Consider the following open network, where a and b are routing probabilities. Which is the number of visits at station 2?



☐ A $a/(1-b)$ ■ $(1-a)/(1-b)$ ☐ C $2-a$ ☐ D $1/(1-b)$

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): 0.9
- Visits station B (Vb): 1.3
- Service time station A (Sa): 0.17 sec/tran
- Service time station B (Sb): 0.32 sec/tran
- Arrival rate (λ): 1.72 tran/sec

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

☐ A 2.818 sec/tran ☐ B 1.336 sec/tran ☐ C 0.570 sec/tran ■ 1.654 sec/tran

Explanation: $R(\lambda) = \frac{D_a}{1-U_a} + \frac{D_b}{1-U_b} = \frac{S_a V_a}{1-\lambda S_a V_a} + \frac{S_b V_b}{1-\lambda S_b V_b} = \frac{0.17\times0.9}{1-1.72\times0.17\times0.9} + \frac{0.32\times1.3}{1-1.72\times0.32\times1.3} =$ 1.654

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