# Computing Infrastructures

Course 095897

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| Student ID (codice persona): | Last Name / Cognome: |
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| | First Name / Nome: |
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**Answers must be given exclusively on the answer sheet (last sheet): DO NOT FILL ANY BOX IN THIS SHEET**

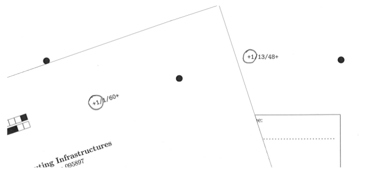
Students must use pen (black or blue) to mark answers (no pencil).
Students are permitted to use a non-programmable calculator.

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 with 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

**Question 1:** ■A □B □C □D
**Question 2:** □A □B ■C □D
**Question 3:** □A ■B □C □D
**Question 4:** □A □B □C ■D

Do not use crosses to mark the answers! Completely fill the box!

A **Question 9:** □A □B ■C □D
**Question 10:** □A □B ■C □D
**Question 11:** ■A □B □C □D

If you make a mistake:

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

**Answer sheet:** 104238 12

Student ID (codice persona):

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| □4 | □4 | ■4 | □4 | □4 | □4 | □4 | □4 |
| □5 | □5 | □5 | □5 | □5 | □5 | □5 | □5 |
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Enter the numbers of your "Student ID" from left to right

**Question 1** Which statement about Full -Virtualization is correct?

- [ ] A Hooks are required
- [ ] B Cannot be used with traditional Operating Systems
- [ ] C Occurs at Operating System-level by means of private Servers
- [x] Requires the hypervision mediation

***Explanation:***

**Question 2** Gmail is an example of

- [ ] A Platform as a Service
- [ ] B Infrastructure as a service
- [ ] C Communication as a service
- [x] Software as a Service

***Explanation:***

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

**Question 3** MTBF is calculated as:

- [ ] A MTBF does not exist
- [ ] B $\frac{1}{MTTF}$
- [ ] C $\frac{1}{MTTF+MTTR}$
- [x] $MTTF+MTTR$

***Explanation:***
Mean Time Between Failures is calculated as MTTF + MTTR.

**Question 4**
Consider two components A and B in a serial configuration. They have the following characteristics: $MTTF_A = 700\ days$, $MTTR_A = 5\ days$; $MTTF_B = 100\ days$, $MTTR_B = 2\ days$.
It is required to change component B in order to achieve a system MTTF, computed without repair, equal to $MTTF_{Sys} = 167$. The required upgrade is:

- [x] $MTTF_B = 219$
- [ ] B $MTTF_B = 143$
- [ ] C $MTTF_B = 350$
- [ ] D Impossible

***Explanation:***
$MTTF_{Sys} = 167 = \frac{1}{\frac{1}{MTTF_A}+\frac{1}{MTTF_B}} = \frac{MTTF_A MTTF_B}{MTTF_A+MTTF_B}$

$MTTF_B = \frac{MTTF_A MTTF_{Sys}}{MTTF_A - MTTF_{Sys}} = \frac{700\times167}{700-167} = 219$

**Question 5**
A system is composed of two identical devices $d$. If $MTTF_d = 500000$, which is the probability that at least one of them fails?

- [x] 0.0998
- [ ] B 0.0512
- [ ] C 0.9002
- [ ] D 0.9488

***Explanation:***
$P(X \leq t) = 1 - e^{-hours/MTTFd*2}$

**Question 6** The Nested Pages mechanism:

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

***Explanation:***
Lesson_3_Virtualization_B.pdf, slide 31

**Question 7** 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] 192.168.0.3 is a possible IP address for VM1 on the hosts' subnet
- ■ a service running inside VM2 and listening on port 8080 can be reached at the address: 192.168.0.1:8080
- [D] a service running inside VM3 and listening on port 22 can be reached at the address: 192.168.0.2:22

***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 8** Consider 5 Virtual Machines (VMs) on 4 different Physical Machines (Hosts):

- Host1 @ 192.168.0.1 runs VM1 and VM2, connected with internal networking;
- Host2 @ 192.168.0.2 runs VM3, attached to its Bridge adapter;
- Host3 @ 10.0.0.1 runs VM4, attached to the NAT adapter;
- Host4 @ 10.0.0.2 runs VM5, attached to the NAT adapter;

Assuming that the network connecting all the hosts is configured to enable them to see each others (i.e.: Host1 can see Host3):

[A] none of the other answers is valid
[B] a service on VM1 can reach a service on VM4 if port-forwarding is configured for VM4
■ a service on VM4 can reach a service on VM5 if port-forwarding is configured for VM5 but not for VM4
[D] port-forwarding needs to be configured to expose services running on VM2

***Explanation:***
Services running on VM1 and VM2 cannot be accessed from outside and cannot reach the external network; with NAT, a VM can reach the outside network even if port-forwarding is not enabled for itself, while it has to be enabled to receive connections from outside.

**Question 9**
Consider a HDD with:

- data transfer rate: 260 MB/s
- rotation speed: 11000 RPM
- mean seek time: 15 ms
- overhead controller: 0.9 ms

The minimum locality required to achieve a mean I/O service time of 14.90 ms to transfer a sector of 1 KB will be:

[A] 0.05 [B] none of the others ■ 0.21 [D] 0.15

***Explanation:***
Mean latency: (1/2 round) * (60s/min) * 1/(11000 round/min) = 2.7273 ms
Transfer time: (1 KB) / (260 * 1024 KB/s) = 0.0038 ms
Mean I/O service time (no locality) = 15 + 2.7273 + 0.9 + 0.0038 = 18.6311
Target mean I/O service time = 14.90 = (1 - locality) * (15 + 2.7273) + 0.9 + 0.0038
Locality (minimum) = 1 - (14.90 - 0.9 - 0.0038) / (15 + 2.7273) = 0.21

**Question 10**
Consider 2 groups (RAID 1) of 4 disks each (RAID 0), for a total of 8 disks in configuration RAID 0+1:

- MTTR = 4 days
- MTTF(one disk) = 2300 days

The MTTDL will be:

A none of the others   B 661250 days   ■ 41328 days   D 165312 days

***Explanation:***
$MTTDL = (2 * MTTF^2)/((totaldisks)^2 * MTTR) = 41328 days$

**Question 11**
Consider the following RAID 0 setup:

- n = 5 disks
- MTTR = 7 hours
- MTTF(one disk) = 1800 day

The MTTDL will be:

A none of the others   B 257 days   ■ 360 days   D 257 hours

***Explanation:***
MTTDL = MTTF(1 disk) / n = 360 days (as MTTDL does not depend on MTTR)

**Question 12**

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

- Monitoring period: 5 minutes
- Disk utilization: 0.32
- CPU utilization: 0.62
- CPU demand: 0.39 seconds/transaction
- Number of I/O operations / transaction 9
- Response time: 17 seconds/transaction
- Number of users: 44

Which is the average think time of these users?

[A] 8.41 sec [B] 5.79 sec ■ 10.68 sec [D] 27.68 sec

***Explanation:***

Z = N/X - R

X = Ucpu / Dcpu

**Question 13**

Consider a closed system with the following data: average number of users: 24 ($N = 24$) average response time: 31 sec ($R = 31$), average throughput: 0.48 trans/sec ($X = 0.48$), average CPU service demand: 0.66 sec/trans ($D_{\text{CPU}} = 0.66$). Which is the average think time $Z$ of a user?

[A] 36.36 sec ■ 19.00 sec [C] 50.00 sec [D] 5.36 sec

***Explanation:***

Z = N/X - R

**Question 14**
By monitoring a single class iteractive system, we are able to measure the following data:

- Monitoring period: 120 seconds
- CPU service time: 0.37 seconds/operation
- CPU utilization: 0.55
- Disk throughput: 6 operations/second
- Disk visits: 12 operations/transaction
- Response time: 1.0 seconds/transaction
- Number of users: 21

Which is the average think time of these users?

[A] 119.00 sec   [■] 41.00 sec   [C] 42.00 sec   [D] 2.50 sec

***Explanation:***
X = Xdisk / Vdisk = 0.500000000000000000
Z = N/X - R = 41.00

**Question 15**
Consider the following measurement data for an interactive system

- measurement interval: 4 minutes
- number of users: 47
- number of servers: 18
- average response time per transaction: 21 seconds
- Dmax 1.4 sec/transaction
- Dtot 2.6 sec/transaction
- number of completed transactions: 78

On average, how many users are thinking?

■ 40.18    [B] 30.34    [C] 6.05    [D] 6.83

***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: 17 ($N = 17$) average response time: 38 sec ($R = 38$), average throughput: 0.47 trans/sec ($X = 0.47$), average CPU service demand: 0.78 sec/trans ($D_{\text{CPU}} = 0.78$). Which is the CPU utilization?

[A] 0.63    [B] 0.03    [C] 0.50    ■ 0.37

***Explanation:***
Ucpu = X*Dcpu

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

- service demand Dmax = 0.8 sec
- service demand Dtot = 1.4 sec
- think time Z = 1.1 sec
- number of users N = 3

Which is the asymptotic upper bound of response time?

[A] 1.30 sec [B] 3.10 sec [■] 4.20 sec [D] 3.15 sec

***Explanation:***
$ND = 3 \times 1.4 = 4.20$

**Question 18**
Consider a batch system with one CPU and two disks, for which the following measurements have been obtained:

- Monitoring period: 500 seconds
- CPU busy time: 185 seconds
- Slow disk busy time: 137 seconds
- Fast disk busy time: 301 seconds
- Completed transactions: 100
- CPU completed operations: 100
- Slow disk completed operations: 200
- Fast disk completed operations: 500
- Number of concurrent jobs: 1

Using only the information available, shift files between disks in order to balance load between the two disks and increase the expected maximum throughput. Using asymptotic bounds, which is the maximum throughput for the **new, improved system** after you have moved the files? *Visits are not required to be integer number.*

■ 0.15783   [B] 0.45091   [C] 0.16051   [D] 0.44585

***Explanation:***
Dcpu: 1.85 Dslow: 1.37 Dfast: 3.01
Scpu: 1.850000000000000000 Sslow: 0.685000000000000000 Sfast: 0.602000000000000000
Vcpu: 1 Vslow: 2 Vfast: 5 Vslowb: 3.197080291970802919 Vfastb: 3.637873754152823920
Dbal: 2.190000000000000000 Dtotb: 6.230000000000000000 Dmaxb: 2.190000000000000000
SOLUTION: 0.15783

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

- service demand Dmax = 0.7 sec
- service demand Dtot = 3.1 sec
- think time Z = 2 sec
- number of users N = 3

Which is the asymptotic upper bound of throughput?

A 1.43 tran/sec    B 0.97 tran/sec    ■ 0.59 tran/sec    D 4.29 tran/sec

***Explanation:***
$\min(\frac{N}{D+Z}, \frac{1}{D_{max}}) = \min(\frac{3}{3.1+2}, \frac{1}{0.7}) = 0.59$

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

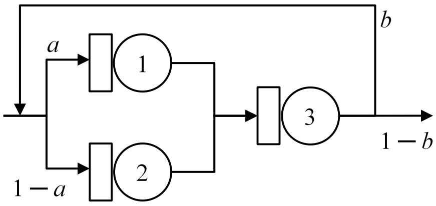
- number of stations K = 2
- service demand Dmax = 1.2 sec
- service demand Dtot = 1.7 sec
- think time Z = 0 sec
- number of users N = 3

Which is the **balanced** lower bound of response time?

A 8.00 sec    ■ 3.60 sec    C 4.25 sec    D 3.40 sec

***Explanation:***
$\max(D_{tot} + (N-1) * D_{avg}, ND_{max} - Z) = \max(1.7 + (3-1) \times 0.85, 3 \times 1.2) = 3.60$

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




A $a/(1-b)$ B $a+ab$ ■ $1/(1-b)$ D $(1-a)/(1-b)$

***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): 1.0
- Service time station A (Sa): 0.50 sec/tran
- Service time station B (Sb): 0.51 sec/tran
- Arrival rate ($\lambda$): 1.66 tran/sec

Which is the system response time?

A 6.266 sec/tran
■ 6.266 sec/tran
C 10.401 sec/tran
D 1.010 sec/tran