



Computing Infrastructures

June 12, 2025

Course Section: Prof. Ardagna Prof. Palermo Prof. Roveri

Student ID (Codice Persona):

Last Name:
(LAST NAME IN CAPITAL LETTERS)

First Name:
(FIRST NAME IN CAPITAL LETTERS)

Exam Duration: 1hour and 30min

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**True false questions**

Correct answer: +1, No answer: 0, Wrong Answer -0.5

Answers must be given on the ANSWER SHEETS. Any box filled here will be ignored. Pay attention to the position (A or B) of the True/False answers, since they are not always in the same position.

Question 1 Cloud architectures can be deployed on-premises, in a public cloud, or in a hybrid environment.

A True

B False

Question 2 TPUs require specialized software libraries and frameworks to fully utilize their capabilities.

A False

B True

Question 3 Virtualization is only suitable for running non-critical applications and workloads.

A True

B False

Question 4 Blade servers universally reduce hardware expenses, ensuring they cost far less than rack servers in every scenario.

A False

B True

Question 5 FPGAs are widely adopted for all large-scale HPC and AI workloads, replacing GPUs in most scenarios.

A True

B False

Question 6 Edge computing nodes often cache and compute on locally produced data to reduce latency and congestion.

A False

B True

Question 7 Data centers require specialized fire suppression systems.

A False

B True

Question 8 DAS storage provides low throughput due to its reliance on a shared network.

A True

B False

Question 9 Direct open-loop cooling is most suitable for hot, humid climates.

A False

B True

Question 10 RAID 5 uses parity data to provide fault tolerance.

A True

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Exercises

Correct answer: +2, No answer: 0.

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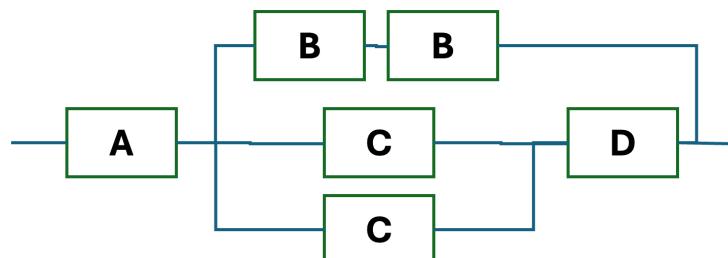
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48, 39, 23, 58, 65

Question 12

Suppose we have a computer system composed of 6 different components, and designed to have an RBD as shown in the image below. The four types of components (A, B, C, and D) have different reliability characteristics. We know that the availability of the components B, C, and D are respectively $Av_A = Av_B = 0.8$, $Av_C = 0.7$, and $Av_D = 0.9$. What is the availability of the entire system? Use always at least 4 decimal digits for each calculation.



$$A_{\text{sequential } B} = Av_B \times Av_B = 0.8 \times 0.8 = 0.64$$

$$A_{\text{parallel } C} = 1 - (1 - 0.7)(1 - 0.7) = 1 - 0.09 = 0.91$$

$$A_{\text{sequential } CD} = 0.91 \times Av_D = 0.91 \times 0.9 = 0.819$$

$$0.8 \times [1 - (1 - \underline{0.64}) \cdot (1 - 0.819)] = 0.748$$



Question 13

A scientific computation uses a server composed of 2 CPUs and 4 GPUs. Knowing that the $MTTF_{CPU} = 380\text{days}$ and $MTTF_{GPU} = 260\text{days}$, and the computation to work requires both CPUs and one GPU within the server to work properly. What is the reliability value after 1/2 years, $R(0.5\text{y})$? Notes: (i) Use at least 4 decimal digits for all the intermediate calculations; (ii) All the other components within the server can be considered as ideal.

$$\begin{aligned}
 & V_{S2} = D_{S2}/X \rightarrow D_{S2} = 0.6668 \\
 & R_{CPU} = e^{-\frac{0.5 \times 365}{380}} \approx 0.6186 \\
 & R_{GPU} = e^{-\frac{0.5 \times 365}{260}} \approx 0.4955 \\
 & R_{System} = R_{CPU} \cdot R_{GPU} = 0.6186^2 \times [1 - (1 - 0.4955)^4] \\
 & = 0.3578 \approx 0.358
 \end{aligned}$$

Question 14

A video rendering system consists of three components: a GPU Server (GS), which processes rendering tasks, a Model Cache Server (MCS) which manages 3D assets, and a Frame Buffer Server (FBS) which handles output frames. The main data obtained from the logging system are reported below:

Service time: $S_{GS} = 20\text{s}$, Visits: $V_{GS} = 21$ visits

Service time: $S_{MCS} = 40\text{s}$, Visits: $V_{MCS} = 12$ visits

Service time: $S_{FBS} = 10\text{s}$, Visits: $V_{FBS} = 80$ visits

Additionally, the system serves $N=5$ users characterized by a think time $Z = 600\text{s}$

What is the system bottleneck (i.e. GS, MCS or FBS)?

FBS



Question 15

Considering the system described in Question 14, compute: a) the maximum system throughput in *jobs/min*, b) the minimum response time in *minutes*.

Question 16

Given the system described in Question 14, you now have the opportunity to enhance its performance by adding exactly one additional server. However, you can only duplicate one of the three existing servers: GS, MCS or FBS. The new server will be identical to the other of the same type (homogeneous), and you can distribute the workload (visits) evenly between them. Assume that all the other system monitoring metrics remain unchanged. Answer the following: a) which one do you choose? (i.e. GS, MCS, FBS) b) What will be the new minimum response time in *minutes*?

$$\begin{aligned}
 D_{GS} &= S_{GS} \cdot V_{GS} = 20 \times 21 = 420 \\
 D_{MCS} &= S_{MCS} \cdot V_{MCS} = 40 \times 12 = 480 \\
 D_{FBS} &= S_{FBS} \cdot V_{FBS} = 10 \times 80 = 800 \\
 \text{Due to think time:} \\
 X &= \frac{5}{D + x} = 0.002 \\
 \text{Due to device bottleneck} \\
 X &= \frac{1}{D_{max}} = \frac{1}{800} = 0.00125 \times 60 = 0.075 \\
 R(N) &\geq \max(D, N \times D_{max} - x) = 56.67 \\
 \text{Duplicate FBC} \\
 \downarrow \\
 D_{max} &= 480 \rightarrow \max(D, N \times D_{max} - x) = 30 \text{ min}
 \end{aligned}$$



Open Questions

Correct answer: +5, No answer: 0. Points are modulated considering the written text

Write the answer using ONLY the space available in the boxes on the ANSWER SHEETS. The answers should be readable by the professor. Unreadable answers will be considered wrong.

Question 17

⇒ Deep learning is transforming data-center technology. From a technological standpoint, how would you design a data center purpose-built for deep-learning workloads?

Question 18

⇒ In a data-center storage context, focusing exclusively on write performance, under what circumstances would you choose RAID 1+0 and under what circumstances RAID 5? Please explain your reasoning.

!!!ANY ANSWER PROVIDED ON THIS PAGE WILL BE IGNORED!!!

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Answer Sheets (Page 1)

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From compute infrastructure perspective,

Hardware:

GPU: Use Nvidia GPU like A100

TPU: Use TPU for tensor computation, but we can only use it as cloud service

CPU: Use high throughput CPU for I/O, multiple core CPU

Interconnects:

NVLink: high bandwidth for GP-GPU communication

PCIe: Connection between CPU, GPU, memory to reduce latency

Storage:

NVMe SSDs: For training dataset or checkpoint because of its high performance

HDD array: ~~SSD~~ storage less-frequently accessed data

Network:

Spine-leaf networking = high-bandwidth, redundant design.



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Answer Sheets (Page 2)

Question 18

⇒ In a data-center storage context, focusing exclusively on write performance, under what circumstances would you choose RAID 1+0 and under what circumstances RAID 5? Please explain your reasoning.

CHOOSE RAID 1+0:

① The application is write-intensive. Because RAID 1+0 has more powerful write performance than RAID 5

② You can afford to trade storage efficiency for speed. Because the storage efficiency is 50%, lower than RAID 5's

③ Need high fault tolerance, RAID 1+0 can tolerate multiple drive failures.

CHOOSE RAID 5:

① The workload is primarily read-intensive

② The budget is limited, because the storage efficiency is $\frac{N-1}{N}$



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Answer Sheets (Page 3)

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True/False Questions

Question 01 : A B

Question 02 : A B

Question 03 : A B

Question 04 : A B

Question 05 : A B

Question 06 : A B

Question 07 : A B

Question 08 : A B

Question 09 : A B

Question 10 : A B

Exercises

48 39 23 58 65

Question 11 :

0,748

Question 12 :

0,358

Question 13 :

FBS

Question 14 :

0,075 Jobs/min. 56,667 min

Question 15 :

FBS. 30min

Question 16 :



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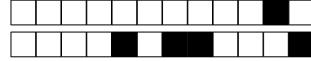
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- A False B True

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- A True B False

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Exercises

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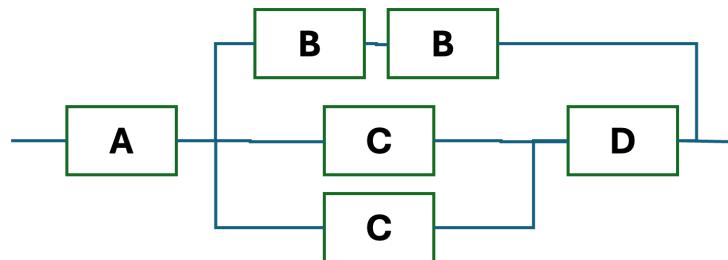
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Service time: $S_{FBS} = 10\text{s}$, Visits: $V_{FBS} = 80$ visits

Additionally, the system serves $N=7$ users characterized by a think time $Z = 600\text{s}$

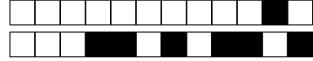
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Question 09 : A B

Question 10 : A B

Exercises

48 39 23 65 58 (accepted also 58 65 23 39 48)

Question 11 :

0,748

Question 12 :

0,358

Question 13 :

FBS

Question 14 :

0,075 Job/min. 83,333 min

Question 15 :

Question 16 : ...**FBS. 55,333 min.**.....



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B True

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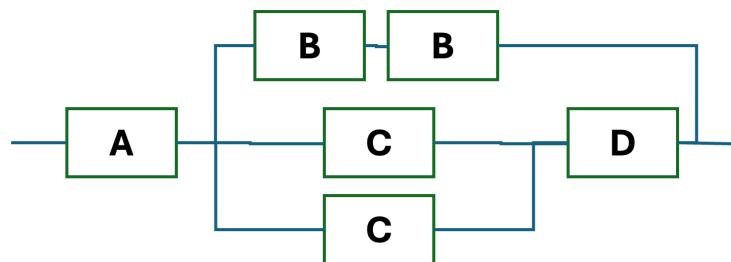
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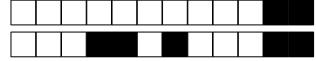
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Question 10 : A B

Exercises

58 65 23 39 48

Question 11 :

0,5891

Question 12 :

0,358

Question 13 :

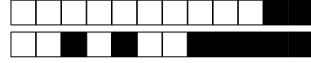
FBS

Question 14 :

0,075 Job/min. 123,333 min

Question 15 :

Question 16 : ...**FBS.**...**70 min**.....



Computing Infrastructures

June 12, 2025

Course Section: Prof. Ardagna Prof. Palermo Prof. Roveri

Student ID (Codice Persona):

Last Name:
(LAST NAME IN CAPITAL LETTERS)

First Name:
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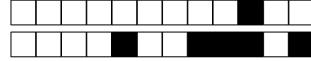
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**True false questions**

Correct answer: +1, No answer: 0, Wrong Answer -0.5

Answers must be given on the ANSWER SHEETS. Any box filled here will be ignored. Pay attention to the position (A or B) of the True/False answers, since they are not always in the same position.

Question 1 Data centers require specialized fire suppression systems.

- A True B False

Question 2 Edge computing nodes often cache and compute on locally produced data to reduce latency and congestion.

- A True B False

Question 3 RAID 5 uses parity data to provide fault tolerance.

- A True B False

Question 4 DAS storage provides low throughput due to its reliance on a shared network.

- A True B False

Question 5 Direct open-loop cooling is most suitable for hot, humid climates.

- A False B True

Question 6 FPGAs are widely adopted for all large-scale HPC and AI workloads, replacing GPUs in most scenarios.

- A True B False

Question 7 Blade servers universally reduce hardware expenses, ensuring they cost far less than rack servers in every scenario.

- A False B True

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Question 9 TPUs require specialized software libraries and frameworks to fully utilize their capabilities.

- A True B False

Question 10 Cloud architectures can be deployed on-premises, in a public cloud, or in a hybrid environment.

- A False B True



Exercises

Correct answer: +2, No answer: 0.

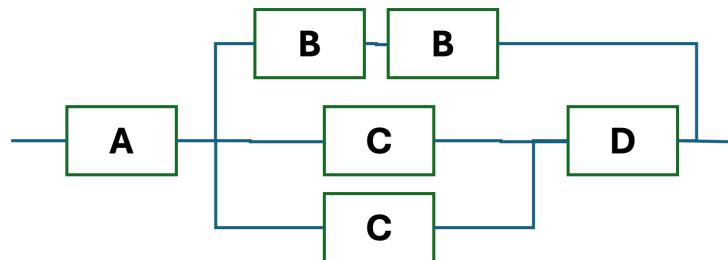
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Let us consider a set of requests in the disk queue referring to the following cylinders of the disk: 65, 23, 58, 48, 39. Consider the initial position of the disk head at cylinder 53 and it is moving from outside (higher cylinder number) to inside (lower cylinder number). If no further requests arrive, write the order of the served requests (from the first to the last) if the disk head scheduling algorithm adopted is C-SCAN? Use the cylinder number to refer to the request.

Question 12

Suppose we have a computer system composed of 6 different components, and designed to have an RBD as shown in the image below. The four types of components (A, B, C, and D) have different reliability characteristics. We know that the availability of the components B, C, and D are respectively $Av_A = Av_B = 0.8$, $Av_C = 0.7$, and $Av_D = 0.9$. What is the availability of the entire system? Use always at least 4 decimal digits for each calculation.



**Question 13**

A scientific computation uses a server composed of 2 CPUs and 4 GPUs. Knowing that the $MTTF_{CPU} = 380\text{days}$ and $MTTF_{GPU} = 260\text{days}$, and the computation to work requires both CPUs and one GPU within the server to work properly. What is the reliability value after 1/2 years, $R(0.5y)$? Notes: (i) Use at least 4 decimal digits for all the intermediate calculations; (ii) All the other components within the server can be considered as ideal.

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A video rendering system consists of three components: a GPU Server (GS), which processes rendering tasks, a Model Cache Server (MCS) which manages 3D assets, and a Frame Buffer Server (FBS) which handles output frames. The main data obtained from the logging system are reported below:

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Service time: $S_{MCS} = 40\text{s}$, Visits: $V_{MCS} = 12$ visits

Service time: $S_{FBS} = 10\text{s}$, Visits: $V_{FBS} = 80$ visits

Additionally, the system serves $N=5$ users characterized by a think time $Z = 600\text{s}$

What is the system bottleneck (i.e. GS, MCS or FBS)?

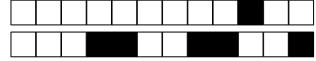


Question 15

Considering the system described in Question 14, compute: a) the maximum system throughput in *jobs/min*, b) the minimum response time in *minutes*.

Question 16

Given the system described in Question 14, you now have the opportunity to enhance its performance by adding exactly one additional server. However, you can only duplicate one of the three existing servers: GS, MCS or FBS. The new server will be identical to the other of the same type (homogeneous), and you can distribute the workload (visits) evenly between them. Assume that all the other system monitoring metrics remain unchanged. Answer the following: a) which one do you choose? (i.e. GS, MCS, FBS) b) What will be the new minimum response time in *minutes*?



Open Questions

Correct answer: +5, No answer: 0. Points are modulated considering the written text

Write the answer using ONLY the space available in the boxes on the ANSWER SHEETS. The answers should be readable by the professor. Unreadable answers will be considered wrong.

Question 17

⇒ Deep learning is transforming data-center technology. From a technological standpoint, how would you design a data center purpose-built for deep-learning workloads?

Question 18

⇒ In a data-center storage context, focusing exclusively on write performance, under what circumstances would you choose RAID 1+0 and under what circumstances RAID 5? Please explain your reasoning.

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Computing Infrastructures - June 12, 2025

Answer Sheets (Page 1)

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Student ID (Codice Persona):

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Computing Infrastructures - June 12, 2025

Answer Sheets (Page 2)

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Computing Infrastructures - June 12, 2025

Answer Sheets (Page 3)

Student ID (Codice Persona):

True/False Questions

Question 01 : A B

Question 02 : A B

Question 03 : A B

Question 04 : A B

Question 05 : A B

Question 06 : A B

Question 07 : A B

Question 08 : A B

Question 09 : A B

Question 10 : A B

Exercises

48 39 23 65 58 (accepted also 58 65 23 39 48)

Question 11 :

0,748

Question 12 :

0,358

Question 13 :

FBS

Question 14 :

0,075 Job/min. 56,667 min

Question 15 :

Question 16 : ...**FBS..30 min**.....



Computing Infrastructures

June 12, 2025

Course Section: Prof. Ardagna Prof. Palermo Prof. Roveri

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Question 1 FPGAs are widely adopted for all large-scale HPC and AI workloads, replacing GPUs in most scenarios.

[A] False

[B] True

Question 2 Blade servers universally reduce hardware expenses, ensuring they cost far less than rack servers in every scenario.

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[B] True

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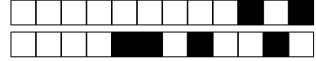
[A] False

[B] True

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[A] False

[B] True



Exercises

Correct answer: +2, No answer: 0.

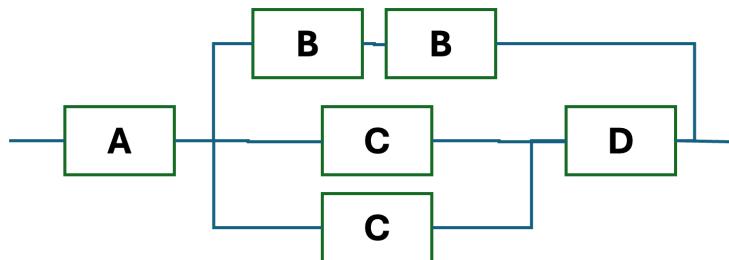
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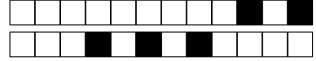
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Service time: $S_{FBS} = 10\text{s}$, Visits: $V_{FBS} = 80$ visits

Additionally, the system serves $N=7$ users characterized by a think time $Z = 600\text{s}$

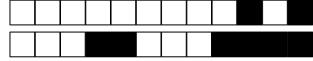
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Computing Infrastructures - June 12, 2025

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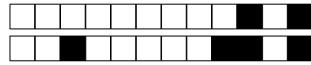
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Computing Infrastructures - June 12, 2025

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Computing Infrastructures - June 12, 2025

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Student ID (Codice Persona):

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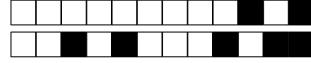
FBS

Question 14 :

0,075 Job/min. 83,333 min

Question 15 :

Question 16 : ...**FBS. 55,333 min.**.....



Computing Infrastructures
June 12, 2025

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Exercises

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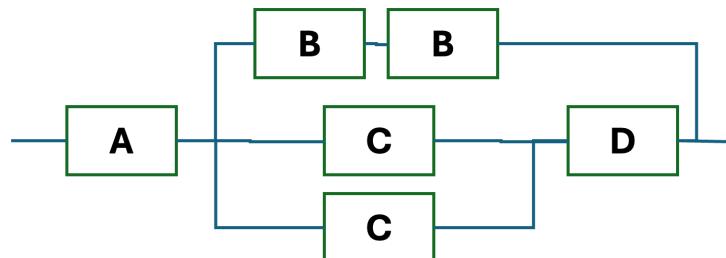
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+6/4/7+

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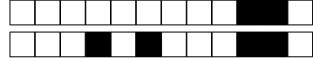
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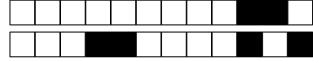
+6/5/6+

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+6/6/5+

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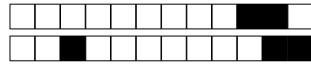
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+6/9/2+

Computing Infrastructures - June 12, 2025

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Question 03 : A B

Question 04 : A B

Question 05 : A B

Question 06 : A B

Question 07 : A B

Question 08 : A B

Question 09 : A B

Question 10 : A B

Exercises

58 65 23 39 48

Question 11 :

0,748

Question 12 :

0,358

Question 13 :

FBS

Question 14 :

0,075 Job/min. 56,667 min

Question 15 :

Question 16 : ...**FBS.** **30 min**.....



Computing Infrastructures
June 12, 2025

Course Section: Prof. Ardagna Prof. Palermo Prof. Roveri

Student ID (Codice Persona):

Last Name:
(LAST NAME IN CAPITAL LETTERS)

First Name:
(FIRST NAME IN CAPITAL LETTERS)

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If needed, you can use this page for notes. Any answer written here will be ignored.