

## OPERATING SYSTEMS

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### HOMEWORK 7

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9.3

Given,

Logical Address= Physical Address= 12 bits

Page size = 256 bytes =  $2^8$  = 8 bits

Logical Address is made up of page number and offset. Number of bits for page number is  $12 - 8 = 4$ ; Number of bits for offset = remaining 8 bits

All the Logical Addresses mentioned here are in Hexadecimal, So we convert everything to binary, take the first 4 bits for page number and remaining for offset.

a. 9EF=100111101111(In Binary)

First 4 bits (1001) determines page number

Therefore page number = 9, corresponding Frame number is 0

**Therefore Physical Address for 9EF=0EF**

b. 111=000100010001(In Binary)

First 4 bits (0001) determines page number

Therefore page number = 1, corresponding Frame number is 2

**Therefore Physical Address for 111=211**

c. 700=011100000000(In Binary)

First 4 bits (0111) determines page number

**Therefore page number = 7, corresponding Frame is not available in the page table,  
Therefore we micro secondse he first free frame i.e D**

**Therefore Physical Address for 700=D00**

d. 0FF=000011111111(In Binary)

First 4 bits(0000) determines page number

**Therefore page number = 0, corresponding Frame is not available in the page table,  
Therefore we micro secondse the next free frame i.e E**

**Therefore Physical Address for 0FF=EFF**

9.8

Reference String

1, 2, 3, 4, 2, 1, 5, 6, 2, 1, 2, 3, 7, 6, 3, 2, 1, 2, 3, 6.

a.LRU

i)Frame Size 1:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6

**No of page faults = 20**

ii)Frame Size 2:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	3	3	2	2	5	5	2	2	2	2	7	7	3	3	1	1	3	3
	2	2	4	4	1	1	6	6	1	1	3	3	6	6	2	2	2	2	6

**No of page faults = 18**

iii) Frame Size 3:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	1	4	4	4	5	5	5	1	1	1	7	7	7	2	2	2	2	2
	2	2	2	2	2	2	6	6	6	6	3	3	3	3	3	3	3	3	3
		3	3	3	1	1	1	2	2	2	2	2	6	6	6	1	1	1	6

**No of page faults = 15**

iv) Frame size 4:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	1	1	1	1	1	1	1	1	1	1	1	6	6	6	6	6	6	6
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		3	3	3	3	5	5	5	5	5	3	3	3	3	3	3	3	3	3
			4	4	4	4	6	6	6	6	6	7	7	7	7	1	1	1	1

**No of page faults = 10**

v)Frame size 5:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		3	3	3	3	3	6	6	6	6	6	6	6	6	6	6	6	6	6
			4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4
						5	5	5	5	5	5	5	5	5	5	5	5	5	5

**No of page faults = 8**

v)Frame size 6:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
			4	4	4	4	4	4	4	4	4	7	7	7	7	7	7	7	7
						5	5	5	5	5	5	5	5	5	5	5	5	5	5
							6	6	6	6	6	6	6	6	6	6	6	6	6

**No of page faults = 7**

v)Frame size 7:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
						5	5	5	5	5	5	5	5	5	5	5	5	5	5
							6	6	6	6	6	6	6	6	6	6	6	6	6
												7	7	7	7	7	7	7	7

**No of page faults = 7**

**b. FIFO Replacement**

i)Frame Size 1:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6

**No of page faults = 20**

ii)Frame Size 2:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	3	3	2	2	5	5	2	2	2	3	3	6	6	2	2	2	3	6
	2	2	4	4	1	1	6	6	1	1	1	7	7	3	3	1	1	1	1

**No of page faults = 18**

iii) Frame Size 3:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	1	4	4	4	4	6	6	6	6	3	3	3	3	2	2	2	2	6
	2	2	2	2	1	1	1	2	2	2	2	7	7	7	7	1	1	1	1
		3	3	3	3	5	5	5	1	1	1	1	6	6	6	6	6	3	3

**No of page faults = 16**

iv) Frame size 4:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	1	1	1	1	5	5	5	5	5	3	3	3	3	3	1	1	1	1
	2	2	2	2	2	2	6	6	6	6	6	7	7	7	7	7	7	3	3
		3	3	3	3	3	3	2	2	2	2	2	6	6	6	6	6	6	6
			4	4	4	4	4	4	4	1	1	1	1	1	1	2	2	2	2

**No of page faults = 14**

v)Frame size 5:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	1	1	1	1	1	6	6	6	6	6	6	6	6	6	6	6	6	6
	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
		3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2
			4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3
						5	5	5	5	5	5	7	7	7	7	7	7	7	7

**No of page faults = 10**

v)Frame size 6:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	1	1	1	1	1	1	1	1	1	1	7	7	7	7	7	7	7	7
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2
			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3
						5	5	5	5	5	5	5	5	5	5	5	5	5	5
							6	6	6	6	6	6	6	6	6	6	6	6	6

**No of page faults = 10**

v)Frame size 7:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
						5	5	5	5	5	5	5	5	5	5	5	5	5	5
							6	6	6	6	6	6	6	6	6	6	6	6	6
												7	7	7	7	7	7	7	7

**No of page faults = 7**

## b. Optimal Page Replacement

i)Frame Size 1:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6

**No of page faults = 20**

ii)Frame Size 2:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	3	4	4	1	5	6	6	1	1	3	3	3	3	3	1	1	3	3
	2	2	2	2	2	3	2	2	2	2	2	7	6	6	2	2	2	2	6

**No of page faults = 15**

iii) Frame Size 3:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3	3	6
	2	2	2	2	2	2	2	2	2	2	2	7	7	7	2	2	2	2	2
		3	4	4	4	5	6	6	6	6	6	6	6	6	6	1	1	1	1

**No of page faults = 11**

iv) Frame size 4:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	1	1	1	1	1	1	1	1	1	1	7	7	7	7	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
			4	4	4	5	6	6	6	6	6	6	6	6	6	6	6	6	6

**No of page faults = 8**

v)Frame size 5:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
			4	4	4	4	6	6	6	6	6	6	6	6	6	6	6	6	6
						5	5	5	5	5	5	7	7	7	7	7	7	7	7

**No of page faults = 7**

v)Frame size 6:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
			4	4	4	4	4	4	4	4	4	7	7	7	7	7	7	7	7
						5	5	5	5	5	5	5	5	5	5	5	5	5	5
							6	6	6	6	6	6	6	6	6	6	6	6	6

**No of page faults = 7**

v)Frame size 7:

1	2	3	4	2	1	5	6	2	1	2	3	7	6	3	2	1	2	3	6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
						5	5	5	5	5	5	5	5	5	5	5	5	5	5
							6	6	6	6	6	6	6	6	6	6	6	6	6
												7	7	7	7	7	7	7	7

**No of page faults = 7**

9.14

- TLB miss with no page fault: It is possible, as the page may not be in the TLB, but can be in the Page Table.
- TLB miss and page fault: It is possible as the requested page may not be in both TLB as well as page table.
- TLB hit and no page fault: It is possible as the page will be in TLB leading to no page fault.
- TLB hit and page fault: It is not possible to have both TLB hit and page fault.

9.18

a. Given Virtual Address is 11123456. Corresponding Binary Value is

0001 0001 0001 0010 0011 0100 0101 0110

Page size is 4096 bytes= $2^{12}$

Therefore page number includes 20 bits. Offset includes 8 bits.

First 20 bits to index the page's corresponding frame number and the offset is added to the frame obtained.

b. For establishing a physical location, we perform DAT, set up TLB, Page tables as well as handle page faults.

- The DAT operation, TLB and Page Faults is handled by the hardware.
- Servicing a page fault, mapping physical to logical addresses will be done by the software.

9.19

Effective memory access time,

$EAT = (1-P) * \text{Memory access time} + P * \text{Page Fault Service Time (no modification)} + P * \text{Page Fault Service Time (with modification)}$

$EAT = 200 \text{ nano secs} = .2 \text{ micro seconds}$

$0.2 \text{ micro seconds} = ((1-P) * 0.1 \text{ micro seconds}) + (0.3P * 8,000 \text{ micro seconds}) + (0.7P * 20,000 \text{ micro seconds})$

$0.1 = -0.1P + 2,400P + 14,000P$

$0.1 = 16,400 P$

$P = 0.000006$