CS & IT

Operating System

Memory Management

DPP - 02

Q1 When a program tries to access a page that is mapped in address space but not available in physical memory, then __________ occurs?
(A) segmentation fault
(B) fatal error
(C) page fault
(D) no error

Q2 Effective memory access time for virtual memory, is directly proportional to __________ ?
(A) Page-fault rate
(B) Hit ratio of page access in main memory
(C) Main memory access time
(D) Hit ratio of TLB

Q3 It is advantageous for the page size to be large because ?
(A) Less unreferenced data will be loaded into memory
(B) Virtual address will be smaller
(C) Page table will be smaller
(D) Large program can be run

Q4 A demand paged memory environment has memory access time of 50 microseconds without page fault and with page it is 10 milliseconds. If the page fault rate is 5% then the effective memory access time is _____ microseconds (rounded up to 1 decimal place)?

Q5 A demand paged memory environment has physical memory access time of 50 microseconds and page fault service time of 5000 microseconds if the replaced page is not dirty. The page fault service time of 10 milliseconds if a dirty page is replaced. Assume that among all pages which are getting replaced, only 2% are dirty, and 95% page hit ratio then the effective memory access time is _____ microseconds ?

Q6 A main memory can hold 3-page frames and initially all of them are vacant. Consider the following stream of page requests:
2, 3, 2, 4, 6, 2, 5, 6, 1, 4, 6
If the stream uses FIFO replacement policy, the hit ratio h will be?
(A) 11/3 (B) 1/11
(C) 3/11 (D) 2/11

Q7 In a demand paging system, a page table is held in registers. For a memory access, it takes 2000 milliseconds if there is a page fault; but it takes 10 milliseconds when there is no any page fault. For a page fault rate of 0.01, the effective memory access time (rounded up to1 decimal places) is _________ milliseconds?

Q8 In a paged memory management technique, the total available memory for user processes is 64 KB. The system uses 8KB pages. There are 2 processes P1, P2 to be stored in memory. And the sizes of P1 and P2 are 36 KB and 22 KB respectively. The total amount of internal fragmentation against total allocated space is ____ % (Rounded up to 1 decimal place) ?

Q9 Suppose that we decide to design a virtual memory system with virtual address space of 256GB and each page table entry is of 4 bytes. Assume that each page table is fit into a single physical frame. Further, assume that we are going to design the multi-level paging scheme with no more than two levels of tables. The minimum page size that your system must have _____ Kbytes ?

Q10 A virtual memory system has only 2-page frames which are empty initially. Using demand paging the following sequence of page reference is passed through this system.
6, 2, 5, 2, 5, 6, 5, 6, 2, 6, 5, 6, 5, 2, 6

The minimum possible number of page faults to satisfy all above requests is _____?

Q11 Consider a demand paging environment with 32-bits virtual address and 3-level page tables. The page size used is 2KB and each page table entry is of 4 bytes which includes translation and some extra bits for protection etc. The maximum size of page table required across all the levels is ____Kbytes ?

Q12 Consider a paged memory system with page table size of 8Kbytes. The page size is 16Kbytes. Each page table entry contains frame number and 2 protection bits. The physical address size is 44-bits. The size of logical address is ___________ bits ?

Q13 Consider the following page references:
0, 3, 0, 5, 6, 3, 0, 5, 0, 7, 5, 7, 9, 7
The system is using optimal policy for page replacement and has 4 frames (initially empty). Memory access time is 7 milliseconds when there is not page fault and is 70 milliseconds when there is a page fault. The effective memory access time is _____ milliseconds ?

Answer Key

Q1	C
Q2	A
Q3	C
Q4	547.5
Q5	350
Q6	D
Q7	29.9
Q8	9.4
Q9	16
Q10	7
Q11	8210
Q12	25
Q13	34

Hints & Solutions

Note: scan the QR code to watch video solution

Q1 Text Solution:

When the requested page is not available, in the memory then it is called as page fault.

Q2 Text Solution:

When page fault rate increases then effective memory access time also increases. Rest all 3 options are inversely proportional to the effective memory access time.

Q3 Text Solution:

(A) If page size is large then for a few bytes access, entire big size page will be loaded to memory. In that big size page, so much not referenced data may be present.

(B) Virtual address will not be dependent on page size

(C) Page table size = number of pages * page table entry size

For the larger page size, number of pages in process will be lesser. Hence page table size also will be smaller.

(D) With virtual memory, with any size of page, larger programs can run.

Q4 Text Solution:

Effective memory access time = 0.95* 50 + 0.05 * 10 * 1000 microseconds

= 547.5 microseconds.

Q5 Text Solution:

Effective memory access time = 0.95 *(2 * 50) + 0.05 [0.98 * 5000 + 0.02 * 10000]

= 95 + 255

= 350 microseconds

Q6 Text Solution:

2	**3**	**2**	**4**	**6**	**2**	**5**	**6**	**1**	**4**	**6**
2	2	2	2	6	6	6		1	1	1
	3	3	3	3	2	2		2	4	4
			4	4	4	5		5	5	6
Fault	**Fault**	**Hit**	**Fault**	**Fault**	**Fault**	**Fault**	**Hit**	**Fault**	**Fault**	**Fault**

Page hit ratio = 2/11

Q7 Text Solution:

Effective memory access time = 0.99*10 + 0.01 * 2000

= 9.9 + 20

= 29.9 milliseconds.

Q8 Text Solution:

P1 will need 5 pages of 8KB each to be stored, hence total allocated space = 5*8KB = 40KB

Internal fragmentation = 40-36 = 4KB

P2 will need 3 pages of 8KB each to be stored, hence total allocated space = 3*8KB = 24KB

Internal fragmentation = 24-22 = 2KB

Total Internal fragmentation = 4+2= 6KB

Total allocated space = 40+24 = 64KB

Percentage of Internal fragmentation = (6/64)*100% = 9.375 = 9.4

Q9 Text Solution:

Given virtual address space = 256GB = hence virtual address size= $\log_2 2^{38}$ = 38-bits

Let 2^P bytes be the page size (frame size).

The maximum number of page table entries in single frame = $\frac{2^P \text{ bytes}}{4 \text{ bytes}} = 2^{P-2}$

The virtual address is divided into the 3 parts as follows :

P1	P2	d
P-2	P-2	P

Virtual address = 38 bits = P-2 + P-2 + P

P = 14

Hence page size is = 2^P bytes = 2^{14} bytes = 16kbytes

Q10 Text Solution:

For minimum possible page faults, the optimal page replacement policy will be used.

6	**2**	**5**	**25**	**6**	**56**	**2**	**6**	**5**	**65**	**2**	**5**
6	6	5	55	5	55	2	2	5	55	5	5
	2	2	22	6	66	6	6	6	66	2	2
Fault	**Fault**	**Fault**		**Fault**		**Fault**		**Fault**		**Fault**	

Number of page faults = 7

Q11 Text Solution:

Page size = 2KB = 2^{11}Bytes, hence the bits required for page offset (d) = 11 bits

The number of page table entries possible in one page = 2KB / 4B = 512 = 2^9, hence for each page table indexing or searching 9-bits are required.

The 32-bits virtual address is divided into multiple sections as follows:

P1 P2 P3 d

3 9 9 11

Total number of page tables at first level = 1

Total number of page tables at second level = $2^{p1} = 2^3 = 8$

Total number of page tables at third level = $2^{p1} * 2^{p2} = 8*2^9 = 4096$

Total page tables = 4096 + 8 + 1 = 4105

Hence total page table size required = 4105 * 2KB = 8210

Q12 Text Solution:

Page size = 16Kbytes = 2^{14} bytes

Total number of frames = $2^{44} / 2^{14} = 2^{30}$, hence frame number will be of 30 bits

Each page table entry size = frame number + 2 protection bits = 30+2 = 32 bits = 4 bytes

Number of entries in page table (number of pages in process) = page table size / one entry size

= 8KB / 4B

= $2K = 2^{11}$

Hence number of bits for page number = 11 bits

Page size = 2^{14} bytes, hence offset bits = 14 bits

Logical address size = 14+11 = 25 bits

Q13 Text Solution:

0	**3**	**0**	**5**	**6**	**3**	**0**	**5**	**0**	**7**	**5**	**7**	**3**	**7**
0	0	0	0	0	0	0	0	0	7	7	7	7	7
	3	3	3	3	3	3	3	3	3	3	3	3	3
			5	5	5	5	5	5	5	5	5	5	5
				6	6	6	6	6	6	6	6	6	6
Fault	**Fault**	**Hit**	**Fault**	**Fault**	**Hit**	**Hit**	**Hit**	**Hit**	**Fault**	**Hit**	**Fault**	**Hit**	**Hit**

Number of hits = 8

Number of faults = 6

Fault rate = 6/14

Hit rate = 8/14

Effective access time = (8/14) * 7 + (6/14)*70 = 4 + 30 = 34 milliseconds.