八． **(16 points)Consider a demand-paging based virtual memory system. A process *P* has the logical address space of three pages, and the page size is 4KB. The page table for *P* is as follows:**

page number	frame number	valid-invalid-bit
0	100H	1
1	—	0
2	210H	1

It takes 15ns to search the TLB for address binding and 100ns to access memory respectively. And if a page fault occurs, the OS takes 1000ns on average to handle this trap, including updating the TLB, modifying the page table and page replacement.

It is supposed that

(1) The TLB contains two page-table entries, and is initially empty;

(2) when the CPU generates a logical address, it at first accesses the TLB to obtain the page entry. And if the page number in the logical address is not found, a memory reference to the page table is made, and the page entry for this address is then loaded into the TLB;

(3) for a page entry in the page table, if valid-invalid-bit=0, then the page corresponding to this entry is not in memory, and a page fault occurs;

(4) there are only two frames allocated to *P*, i.e. the frames with the base addresses 100H and 210H respectively.

(5) the local replacement strategy and the LRU algorithm are employed for page replacement by the OS.

Given three logical addresses 0021H, 1300H, and 0100H, if CPU accesses these addresses sequentially,

(1) how long does it takes to access to these three addresses respectively? And

(2) after the page in which the address 1300H resides is loaded into memory, what is the physical address for 1300H ?

Note：For question (1) and (2), not only the calculation results but also the problem solving steps should be illustrated.

答案：

(1) **三个结果，每个结果 4 分； 如果只有结果，没有过程，扣 1.5 分**

Page size=2^{12}B, 16 进制逻辑地址的最高位就是页号,后 3 位为 page offset;

0021H 的页号: 0, 1300H 的页号:1, 0100H 的页号:0

1. 访问 0021H 的时间和物理地址:

Page0 地址变换访问 TLB 15ns(未命中，但将 page0 对应的页表表项调入 TLB)

+ 访问内存页表 100ns（命中，且该页已在内存中）

+ 根据内存页表表项合成得到物理地址后访问内存 100ns

= 215ns

逻辑地址→物理地址: 0021H →100021H

2. 访问 1300H 的时间和物理地址:

page1 地址变换访问 TLB 15ns(未命中，但将 page1 所在页表表项调入 TLB)

+ 访问内存页表 100ns（命中，但该页不在内存中，产生 page fault） + 缺页中断淘汰 page2 调入 page1 1000ns

+ 根据内存页表表项合成得到物理地址后访问内存 100ns

= 1215ns

逻辑地址→物理地址:

page fault 发生时，物理内存中有 page0、page2，由于 page0 刚访问过，采用 LRU 页置换算法，pag2 被置换，被换入的 page1 放入 page2 所在的高位为 254H 的 frame 内

1300H → 210300H

3. 访问 0100H 的时间和物理地址:

Page0 地址变换访问 TLB 15ns(命中)

+ 根据 TLB 页表表项合成得到物理地址后访问内存 100ns

= 115ns

逻辑地址→物理地址:

0100H → 100100H

(2) **只有结果，没有过程，扣 1.5 分**

由于页面大小 4KB，逻辑地址 1300H 对应的页号是 1；

由题目得知，合法驻留集为 2，且此时已经存在 0 和 1 页，现在请求的是 1 号页，已经在内存中，因此用 210 页框号对应的页面；所以 1300H 对应的物理地址是 210300H；