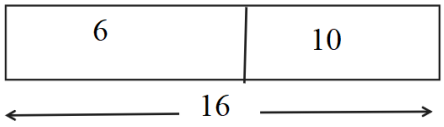
Chapter 9 Main Memory

1. Name two differences between logical and physical addresses.
2. Why are page sizes always powers of 2?
3. Consider a logical address space of 64 pages of 1,024 words each, mapped onto a physical memory of 32 frames.
    a. How many bits are there in the logical address?
    b. How many bits are there in the physical address?
4. Explain the difference between internal and external fragmentation.
5. Assuming a 1-KB page size, what are the page numbers and offsets for the following address references (provided as decimal numbers)?
    a. 308
    b. 42095
    c. 215201
    d. 650000
    e. 2000001
6. The BTV operating system has a 21-bit virtual address, yet on certain embedded devices, it has only a 16-bit physical address. It also has a 2-KB page size.
    a. How many entries are there in a single-level page table?
    b. What is the maximum amount of physical memory?
7. Consider a logical address space of 256 pages with a 4-KB page size, mapped onto a physical memory of 64 frames.
    a. How many bits are required in the logical address?
    b. How many bits are required in the physical address?
8. Consider a computer system with a 32-bit logical address and 4-KB page size. The system supports up to 512 MB of physical memory. \
    a. How many entries are there in a single-level page table?
    b. How many bits are there in the logical address?
    c. How many bits are there in the physical address?
9. What is the purpose of paging the page tables?
10. What is the purpose of a TLB? What actions are taken in the case of a TLB miss?
11. Consider a system with a 32-bit logical address space and a page size of 4KB. How many entries will be in the inner page table in a three-level paging scheme, if the outer page table contains 2^8 entries?
12. On a system with paging, a process cannot access memory that it does not own. Why? (hint: page table)
13. Given six memory partitions of 300 KB, 600 KB, 350 KB, 200 KB, 750 KB, and 125 KB (in order), how would the first-fit, best-fit, and worst-fit algorithms place processes of size 115 KB, 500 KB, 358 KB, 200 KB, and 375 KB (in order)? Rank the algorithms in terms of how efficiently they use memory.
14. How many frames will be allocated for a processor of 72766 bytes, if page size is 2048 bytes?
    a. What will be the internal fragmentation in bytes?

Solutions / hints:

Question 3:

a. Logical address:



Number of pages = 64 = 2^6
Words in each page = 1024 = 2^{10}
2^6 pages, 2^{10} words in each:
Total logical addresses = $2^6 * 2^{10} = 2^{6+10} = 2^{16}$
Number of bits in the logical address = 6 + 10 = 16

b. Physical address:

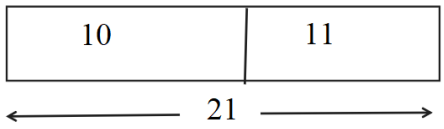
Number of frames = 32 = 2^5
Words in each frame = Words in each page = 1024 = 2^{10}
Total physical addresses = $2^5 * 2^{10} = 2^{5+10} = 2^{15}$
Number of bits in physical addresses= 5 + 10 = 15

Question 5:

Assuming a 1-KB page size, what are the page numbers and offset
Quotient is the page number: page number = 308 / 1024 = 0
Remainder is the offset. Offset = 308 mod 1024 = 308

Question 6.

a. Page size = 2KB = $2*2^{10} = 2^{11}$ 11 bits for offset



Logical address bits = 21 bits
Page Number has 21 – 11 = 10 bits.
Page number first 10 bits Offset: last 11 bits
Page Number has 10 bits. Hence, 2^{10} entries
Conventional, single-level page table will have 2^{10} = 1024 entries.

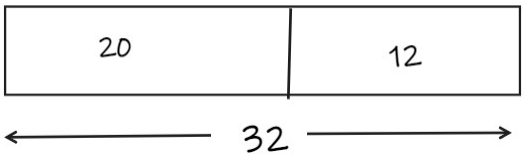
b. 16-bit physical address
Maximum amount of physical memory = 2^{16} = 65536 (or 64-KB)

Question 8:

Refer to answers for questions 3 and 6. Page size is the same as words in each.

Question 10.

32-bit logical address and 4-KB page size. Number of Pages has 32 – 12 = 20 bits
a. An entry for each page. = 2^{20} entries



Question 13.

Worst-fit:

115 KB is put in 750 KB partition, leaving (300 KB, 600 KB, 350 KB, 200 KB, 635 KB, 125 KB)

500 KB is put in 635 KB partition, leaving (300 KB, 600 KB, 350 KB, 200 KB, 135 KB, 125 KB)

358 KB is put in 600 KB partition, leaving (300 KB, 242 KB, 350 KB, 200 KB, 135 KB, 125 KB)

200 KB is put in 350 KB partition, leaving (300 KB, 242 KB, 150 KB, 200 KB, 135 KB, 125 KB)

375 KB must wait