Consider the memory system with the following specifications:

* Byte-addressable
* Virtual address space: 4G bytes
* Main memory size: 16M bytes
* Cache size: 256K bytes
* Page size: 64K bytes
* Block size: 128bytes
* Mapping Strategies: Main Memory to Cache: 4-way set associative; Hard Disk to Main Memory: fully associative

Virtual address is first translated to physical address. Then, it accesses the cache memory using the physical address.

1. How many sets are there in the cache memory?
2. How long is the tag field of the cache?
3. Given a virtual address 0B45DA12 (hexadecimal), its corresponding virtual page is stored in physical page 3E (hexadecimal).
   * + 1. What is its physical address under such mapping?
       2. Which set can this address be possibly found in the cache?
       3. Which byte does this address point to out of the 128 bytes in a block?
4. (256K/128)/4=512

There are 512 sets in the cache memory.

1. Because the main memory is byte-addressable and the main memory size: 16M bytes, so the main memory address is 24-bit long. From (1) there are 512 sets in the cache memory, so the set field of the main memory address is 9-bit long. And because the block size: 128 bytes, so the byte field of the main memory address is 7-bit long. Finally, the tag field of the cache is 24－9－7 =8-bit long.
2. ①There are 4G/64K=216 virtual pages ,so the virtual page number is 16-bit long. Because the virtual address is 32-bit long, so the offset field of it is 32-16=16-bit long.

The virtual address 0B45DA12 can be divided into two parts, the highest 16-bit virtual page number and the lowest 16-bit offset. So the offset field of this virtual address is DA12. Concatenate it with the physical page number. So the physical address under such mapping is 3EDA12.

②3EDA12=(0011 1110 1101 1010 0001 0010)2

So this address can be found in 1B416 or 436 set in the cache.

③3EDA12=(0011 1110 1101 1010 0001 0010)2  The byte number is 18.