Exercise 9: Cache / Virtual Memory

Exercise 9-1(From the textbook problem 5.1)

In this task, we study the characteristics of memory locality in matrix calculation. The code shown below is written in C language.
Multiple elements in the same row are consecutively stored. Let each word be a 32-bit integer.

```
for ( I = 0; I < 8; I++ )
  for ( J = 0; J < 8000; J++ )
    A[I][J] = B[I][0] + A[J][I];
```

(a) How many 32-bit integers can be stored in a 16-byte cache line?
(b) When referring to which variable (element), is temporal locality seen?
(c) Which spatial locality can be seen when referring to variables (elements)?

Exercise 9-2 (From the textbook problem 5.3)

For the design of direct-mapped caches whose address is 32 bits, the bits in the address shown in the table below are used to access the cache.

Tag	Index	Offset
31-10	9-5	4-0

(a) How many block sizes (words) are there in the cache?
(b) How many entries are there in the cache?
(c) What is the relative ratio of the total number of bits required to realize the above cache to the number of bits required to store data?

Exercise9-3

If you use a 64-bit virtual address, find the size of memory that can be accessed by virtual memory.

Exercise9-4

Suppose that the cost per GB of DRAM is 2,000 yen and the cost per GB of HDD is 10 yen. Also, suppose that a budget of 50 million yen is used for each part (1 GB = 2^30 bytes).
In this case, find the maximum size of the physical memory and the virtual memory and the number of bits of the physical address and the virtual address necessary for the access.
Assume that you allocate the full capacity of HDD to virtual memory.