Instructions
Please begin your answer to every problem on a new sheet of paper. Be as concise and clear as you can. Make an effort to be legible. To avoid misplacement of the various components of your assignment, make sure that all the sheets are stapled together. You may discuss problems with your classmates, but all solutions must be written up independently. This homework will help you to advance your ability to apply knowledge in computer engineering learned in the course and knowledge of related topics in computer science discipline.

Problem 1
How many bits are required to implement a direct-mapped cache that can hold 64K bytes of memory data and each cache block hold 4 bytes? Assume every cache block needs one valid bit and the memory address space is 32-bit.

Problem 2
There are generally four aspects need to consider to optimizing the design of a cache memory. Please briefly describe what they are.

Problem 3
Here is a series of address references given as word addresses: 2,4,8,20,18,11,43,17. Show the hits and misses and final cache contents for a direct-mapped cache with four-word blocks and a total size of 16 words.

Problem 4
1. Identify all of the data dependencies in the following codes and draw the dependence graph.
2. Find the hazard in the codes and reorder the instructions to avoid pipeline stalls.

```assembly
lw  $t0, 0($t1)
addi $t3, $t0, 4
sw  $t3, 0($t1)
lw  $t2, 4($t1)
addi $t4, $t2, 4
sw  $t4, 4($t1)
```

Problem 5
Suppose a computer’s main memory is 1024K words, the cache size is 4K words, the block size is 16 words. Figure out how many blocks in the main memory and the cache, and how many bits are required to represent the byte address of the main memory.

Problem 6
The attached figure (Patterson & Hennessy, FIGURE 6.17) is a pipelined datapath to handle the load instruction. Use the following instruction:

```assembly
lw  $t1, 12($t2)
```
as an example to answer the following questions:
1. How many steps it will take to execute the instruction? Please name these steps.
2. Describe the process of each step in detail.