Instructions
Please begin your answer to every problems 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 (15 points)
Figure 5.19 in Patterson and Hennessy’s textbook(page 309) shows the operation of the datapath for an R-type instruction. Take the instruction

\[ \text{add } t1, t2, t3 \]

as example to answer the following questions:
(a) How many steps are needed to execute the instruction? Please name these steps.
(b) Describe the process information for each step in detail.

Problem 2 (15 points)
Do the Problem 5.9 in Patterson and Hennessy’s textbook(see page355).

Problem 3 (20 points)
Find the hazard in the following codes and reorder the instructions to avoid pipeline stalls:

\[
\begin{align*}
\text{lw } t0, 0(t1) \\
\text{lw } t2, 4(t1) \\
\text{sw } t2, 0(t1) \\
\text{sw } t0, 4(t1)
\end{align*}
\]

Problem 4 (20 points)
Do the Problem 6.19 in Patterson and Hennessy’s textbook(see page457).

Problem 5 (15 points)
Do the Problem 6.23 in Patterson and Hennessy’s textbook(see page457).

Problem 6 (15 points)
List and explain the different kinds of hazards in pipelining. Some hazards will not receive full credit without sub-lists.