1. Given the pipeline shown in Figure 1, please answer the following questions:
   1. How can you detect the data dependency between two instructions: one in stage ID and one in stage EX?
   2. Can you detect a data dependency between instructions in the IF and ID stages? Why or why not?
   3. How can the pipeline be flushed? When is this necessary?
   4. How can the pipeline be stalled? When is this necessary?

2. With regard to the following program and the pipeline in Figure 2, explain what the forwarding unit is doing during the fifth cycle of execution.

   add $2, $3, $1
   sub $4, $3, $5
   add $5, $3, $7
   add $7, $6, $1
   add $8, $2, $6
3. With regard to the program of Q2, explain what the hazard detection unit is doing during the fifth cycle of execution.

4. Consider the following code:

\[
\begin{align*}
\text{add} & \quad $5, $6, $7 \\
\text{lw} & \quad $6, 100($7) \\
\text{sub} & \quad $7, $6, $8
\end{align*}
\]

(a) How many clock cycles will the pipeline (shown in Figure 1) take to execute this code? Draw a timing diagram demonstrating the dependencies that need to be resolved.

(b) How many clock cycles will the pipeline (shown in Figure 2) take to execute this code? Draw a timing diagram. How much speedup is achieved as compared to the design in Figure 1?

5. [P&H] 4.16.4