Hazards

- Structural Hazards
  - A required resource is busy
    - More stages means more control hardware: lower bound on cycle time

- Data Hazards
  - Forwarding: retrieving the missing data element from internal buffers rather than waiting for it to arrive from programmer-visible register or memory
  - Load-use data hazard: a specific form of data hazard in which the data being located by a load instruction has not yet become available when it is needed by another instruction.

- Control Hazards
  - Fetching next instruction depends on branch outcome.

- Branch Prediction
  - Assume branch not taken
  - Assume branch always taken: e.g., loop
  - Predict by opcode: figure out if it is loop
  - History-based prediction