Name: _____

CIS 351 Sample P1 Problem

15 October 2025

P1: Pipeline Structure and Speedup

Consider the following process for baking cookies:

1. Mix sugar, flour, and water using a hand-held mixer for six minutes.
2. Pour the mixture into another bowl and add chocolate chips. Stir by hand for four minutes.
3. Spoon the cookie dough onto a baking pan (about four minutes).
4. Place the pan in the oven for fifteen minutes. One pan of cookies takes up the entire oven – you cannot have more than one pan in the oven at once.
5. Place the cookies on a cooling rack (about three minutes). (Assume you have unlimited space on the cooling rack.)

(a) Estimate the total time to bake a single batch of cookies (from when you begin mixing the sugar, flour, and water until all the cookies from the batch are on a cooling rack.)

(b) Suppose you want to pipeline the cookie-baking process, but are working alone. How many stages does your pipeline have? What steps are included in each stage?

(c) What is the primary limitation (i.e., structural hazard) that prevents you from adding a third stage?

(d) Draw a pipeline diagram showing the process of baking 5 batches of cookies using the pipeline you designed above.

(e) Estimate (i) the total time to bake 10 batches of cookies and (ii) the average time per batch.

(f) Your per-batch time is less than the time to make a single batch of cookies. What is the *primary* source of this time savings. (Be specific. Don't just say "pipelining".)

(g) Let k be the number of stages in the pipeline you designed above. The average time per batch is more than $\frac{1}{k}$ the time for a non-pipelined batch. (Using my example, the per-batch time in the 2-stage pipeline — 19.4 minutes – is more than $\frac{1}{2}$ of the 32-minute unpipelined time.)) Explain the primary factor that contributes to this less-than-optimal speedup.

Click here for solutions: `p1_sample_solutions.pdf`