

# MEM6810 Engineering Systems Modeling and Simulation

Sino-US Global Logistics Institute  
Shanghai Jiao Tong University

Spring 2025 (full-time)

## Assignment 4

*Due Date: June 13 (in class)*

### Instruction

- (a) You can answer in English or Chinese or both.
- (b) Show **enough** intermediate steps.
- (c) **Upload the answers in the Canvas system, together with the related Excel, FlexSim, or code files; Late submission will not be accepted.**

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### Question 1 (5 + 10 + 5 = 20 points)

Suppose we run a steady-state simulation, and observe discrete outputs  $Y_1, Y_2, \dots, Y_n$  in one simulation run. Suppose the initialization bias can be ignored. We use  $\bar{Y} = \frac{1}{n} \sum_{i=1}^n Y_i$  as the point estimator of the steady-state performance measure  $\phi$ . The following is a mistake that one will easily make: Calculate  $S^2 = \frac{1}{n-1} \sum_{i=1}^n (Y_i - \bar{Y})^2$ , and use  $\bar{Y} \pm t_{n-1, 1-\alpha/2} \frac{S}{\sqrt{n}}$  as the  $1 - \alpha$  confidence interval for  $\phi$ .

- (1) Why is that a mistake? Briefly explain.
- (2) Suppose  $Y_1, Y_2, \dots, Y_n$  are identically distributed and positively correlated, prove the following:  $\mathbb{E}[S^2] < \text{Var}(Y_1)$ ,  $\mathbb{E}[S^2/n] < \text{Var}(\bar{Y})$ .
- (3) For the situation in (2), if we use  $\bar{Y} \pm t_{n-1, 1-\alpha/2} \frac{S}{\sqrt{n}}$  as the confidence interval, what is the consequence?

### Question 2 (30 points)

Consider an  $M/M/1/5$  queue system, where  $\lambda = 1$ ,  $\mu = 0.8$ . Conduct simulation in Excel or some programming language to estimate  $W'$ ,  $W'_Q$ ,  $W$ ,  $W_Q$ . (It is OK to use Little's Law to help the estimation.) **【Generate around 10000 customers in the simulation.】**

### Question 3 (20+20+10= 50 points)

使用 FlexSim 软件, 完成以下仿真分析.

假设有一间 24 小时咖啡店, 同一时间有 1 位营业员在工作. 顾客到来之后, 排队进行点单. 为简化问题, 现考虑如下的情形:

- 顾客到达的速率保持稳定 (不随时间变化), 到达时间间隔服从指数分布, 均值为 5 分钟.
- 收营员为每个顾客进行结账所需时间服从  $\text{Uniform}(1, 10)$ , 单位为分钟.
- 当进店的顾客, 看到柜台前的顾客**总数** (包括正在点单的顾客) 达到 5 人时, 他/她将直接离开.
- 当顾客进入队伍等待, 如果他/她等了 15 分钟还没轮到, 他/她会感到不耐烦而直接离开 (感到不满意, 这会降低他下次光临该店的意愿).
- 每个成功消费的顾客, 带给咖啡店的利润 (仅扣除了材料成本, 还未扣除租金、人员等成本) 为平均 12 元/人
- 感到不耐烦而离开的顾客, 给咖啡店造成的潜在损失为平均 20 元/人. (注: 他/她可能以后不会再来, 或者建议朋友也不要来.)

建立仿真模型, 运行仿真 100 天, 令 Warmup Time 为 10 天.

(1) 通过仿真计算出下列指标: 每天完成的平均交易数量, 每天感到不耐烦而离开的平均顾客数量.

(2) 假设同一时间工作的营业员数量由 1 位变为 2 位, 并且假设新增的营业员工作效率和已有的相同. 重新建立仿真模型, 并且再次计算下列指标: 每天完成的平均交易数量, 每天感到不耐烦而离开的平均顾客数量.

(3) 假设新引入的营业员的人力成本为 300 元/天. 基于 (1) 和 (2) 中的结果, 请问这样做对咖啡店来说是否划算? 给出计算的方法和结果.

注: 两个仿真模型都要上传 (只需要 .fsm 文件).