Instructions:

1. **The SFU Integrity Code has to be followed.**
2. There is a **No Questions** policy for this exam. This is to ensure that no student gets an advantage by seeking extra information from the instructor. Please make an assumption when you are in doubt. Write down your assumption. We reserve the right to allocate part marks based on your assumption.
3. This is an open book, open notes, open laptop exam. You are welcome to refer to learning material from Canvas.
4. The duration of this exam is 3 hours.
5. Don't panic! There's enough time to answer the questions.
6. There's more to life than marks…

**Good Luck ☺**

1) (10 points) **SafePad** is a home insurance company. Each day the firm receives 20 new requests for insurance from new clients and 10 requests for renewals from existing clients. Clients who are not serviced are lost to competitors. New clients provide $300 in profit contribution while renewals provide $250 in profit contribution. The steps and processing times for each type of request is given below.

   Processing time for each new request:
   Review: 30 min
   Underwriting: 60 min
   Rating: 40 min
   Policy writing: 30 min

   Processing time for each renewal:
   Review: 15 min
   Underwriting: 30 min
   Rating: 20 min
   Policy writing: 15 min

   There are 2 clerks at the review station, 3 clerks at the underwriting station, 2 clerks at the rating station and finally 2 clerks at the policy writing station. Each clerk works for 8 hours every day.

   (a) (5 points) Identify the bottleneck in the process. How much profit contribution/day is the firm forgoing because of inadequate capacity? You may assume that new clients are given preference over renewals.

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## WORKLOAD MATRIX (MIN.)

| | REVIEW | UNDERWRITING | RATING | POLICY WRITING |
|---|---|---|---|---|
| NEW | 30 | 60 | 40 | 30 |
| RENEWALS | 15 | 30 | 20 | 15 |

## RESOURCE REQUIREMENT & CAPACITY (MIN.)

| | REVIEW | UNDERWRITING | RATING | POLICY WRITING |
|---|---|---|---|---|
| NEW (20) | 600 | 1200 | 800 | 600 |
| RENEWALS (10) | 150 | 300 | 200 | 150 |
| TOTAL | 750 | 1500 | 1000 | 750 |
| CAPACITY | 960 | 1440 | 960 | 960 |
| UTILIZATION | 78% | 100% | 100% | 78% |

UNDERWRITING & RATING ARE THE BOTTLENECKS

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ALL NEW CLIENTS WILL BE PROCESSED SINCE THEY'RE GIVEN PREFERENCE. SOME RENEWALS WILL BE LOST. HOW MANY?

FIRST, WE CALCULATE THE RESIDUAL CAPACITY AT UNDERWRITING AFTER WE PROCESS NEW CLIENTS.

RESIDUAL CAPACITY = 1440 − 1200
= 240 MIN.

NUMBER OF RENEWALS PROCESSED

$= \left(\frac{240}{300}\right)(10/\text{DAY}) = 8/\text{DAY}$

∴ NUMBER OF RENEWALS LOST
= 2/DAY

∴ LOST PROFIT = (2/DAY)($250)
= $500/DAY

(b) (5 points) How would you go about improving the process? You have the choice of changing the current policy of giving preference to new clients over existing clients. You may also hire new clerks. The salary/day for an extra clerk at each station is given below:

Review: $150/day
Underwriting: $250/day
Rating: $200/day
Policy writing: $200/day

OPTIONS

1) STATUS QUO

TOTAL PROFIT = (20/DAY)($300)

+ (8/DAY)($250)

− [(2)($150) + (3)($250) + (2)($200) + (2)($200)]

= $6,150/DAY

2) GIVE PREFERENCE TO RENEWALS

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RESIDUAL CAPACITY FOR NEW CLIENTS AT UNDERWRITING

$= 1440 - 300 = 1140$ MIN.

NUMBER OF NEW CLIENTS PROCESSED $= \left(\frac{1140}{1200}\right)(20/\text{DAY}) = 19/\text{DAY}$

$\therefore$ TOTAL PROFIT

$= (19/\text{DAY})(\$300) + (10/\text{DAY})(\$250)$

$- [(2)(\$150) + (3)(\$250) + (2)(\$200) + (2)(\$200)]$

$= \$6,350/\text{DAY}$

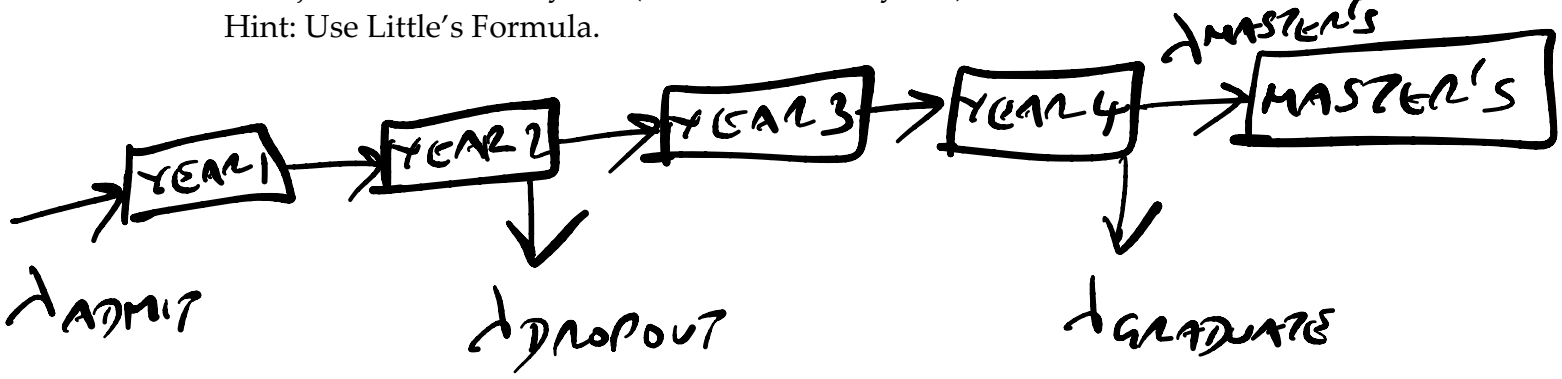
3) HIRE 1 UNDERWRITER + 1 RATER TO RESOLVE PROCESS BOTTLENECK.

TOTAL PROFIT $= (20/\text{DAY})(\$300) + (10/\text{DAY})(\$250)$

$- [(2)(\$150) + (4)(\$250) + (3)(\$200) + (2)(\$200)]$

$= \$6,200/\text{DAY}$ $\therefore$ OPTION 2 IS BEST!

2) (10 points) **UniEd** is a university that admits a certain number of students every year. A freshman (first year) student has 5% chance of dropping out after the sophomore year (second year), 85% chance of graduating after four years and 10% chance of staying an extra year to get a Master's degree. Suppose, on the average, there are 80 students getting a Master's degree. How many students are there, on the average, in their junior and senior years (third and fourth years) at **UniEd**?
Hint: Use Little's Formula.




$$\lambda_{ADMIT} = \lambda_{DROPOUT} + \lambda_{GRADUATE} + \lambda_{MASTER'S}$$
$$(5\%) \qquad (85\%) \qquad (10\%)$$

$T_{MASTER'S} = 1$ YR.

$N_{MASTER'S} = 80$ STUDENTS

$$\therefore \lambda_{MASTER'S} = \frac{N_{MASTER'S}}{T_{MASTER'S}} = \frac{80}{1} = 80/\text{YR}.$$

$$\lambda_{ADMIT} = \frac{80/\text{YR}}{10\%} = 800/\text{YR}.$$

$\lambda_{DROPOUT} = (800/\text{YR})(5\%) = 40/\text{YR}.$

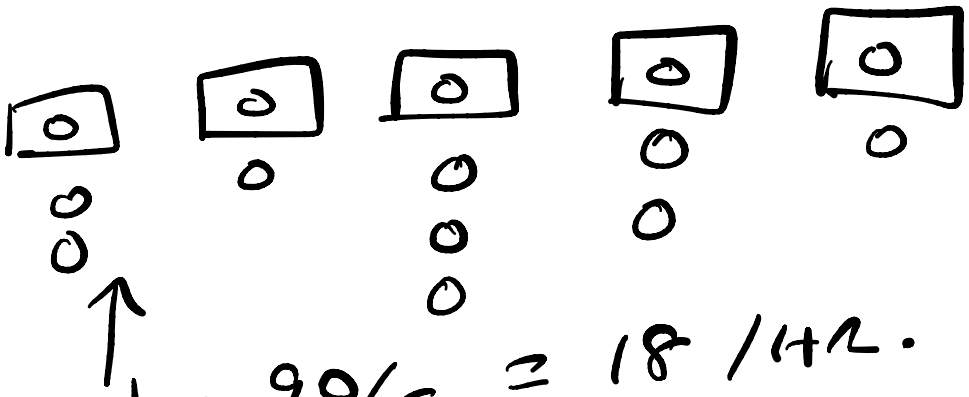
FLOW OF STUDENTS INTO YEAR 3 $= 800 - 40 = 760/\text{YR}.$

$\therefore$ # STUDENTS IN YEAR 3 + YEAR 4 $= (760/\text{YR})(2\ \text{YEARS}) = 1{,}520$ STUDENTS

3) (15 points) The **Joker Hotel** in Las Vegas is considering how to restructure the front desk to reach an optimum level of guest service. At present, the hotel has 5 clerks on duty, each with a separate waiting line, during the peak check-in time of 3 pm to 5 pm. Observations of arrivals during this period shows that an average of 90 guests arrive every hour and join one of the 5 lines with equal probability. It takes an average of 3 minutes for the front desk clerk to register each guest. The management is considering three plans:
   a. The first plan is the status quo (the current configuration).
   b. The second plan would designate one employee as a quick-service clerk for guests who are part of the hotel's loyalty program. The management estimates that 30% of guests are part of the loyalty program. Because loyalty program customers are sort of pre-registered, their registration takes only 2 minutes. With these guests separated from the rest of the clientele, the average time for registering a typical guest would climb to 3.4 minutes. Under this plan, the non-loyalty program guests would choose any of the remaining 4 lines.
   c. The third plan is to implement a single line system with a guest being served by one of the 5 clerks who becomes available. All guests would form a single line to be served by whichever clerk becomes available.

   The management measures customer service by the **average amount of time a guest who is delayed spends waiting in line**. Which plan would you recommend to management? What is the total dollar value of the loss of goodwill per hour in your recommended plan if every hour that a customer waits in line costs $10 in terms of lost customer goodwill.

PLAN 1 : 5 M/M/1 QUEUES



$\lambda = 90/5 = 18/\text{HR}.$

$\mu = (60\ \text{MIN}/3\ \text{MIN}) = 20/\text{HR}.$

$T_{Q,\text{DELAY}} = \frac{T_Q}{P(\text{DELAY})} = \frac{0.45\ \text{HR}}{0.90} = 0.5\ \text{HR}.$

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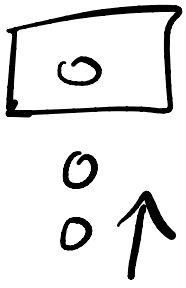
**PLAN 2**: 1 LOYALTY M/M/1 QUEUE + 4 NON-LOYALTY M/M/1 QUEUES



$\lambda = (30\%)(90/HR.)$

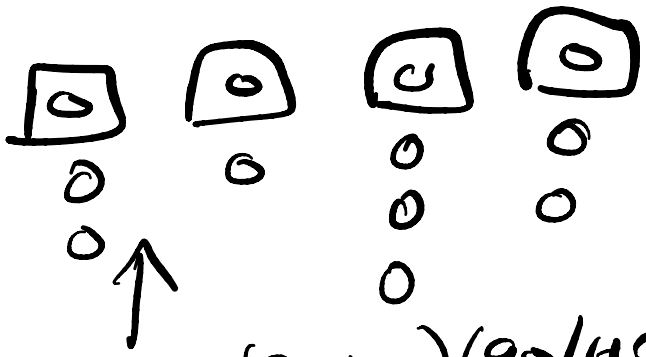
$= 27/HR.$

$\mu = \left(\frac{60\ MIN}{2\ MIN}\right)$

$= 30/HR.$

$T_{Q,DELAY} = \frac{0.3\ HR.}{0.90}$

$= 0.33\ HR.$



$\lambda = \frac{(70\%)(90/HR.)}{4}$

$= 15.75/HR.$

$\mu = \left(\frac{60\ MIN}{3.4\ MIN}\right)$

$= 17.65/HR.$

$T_{Q,DELAY} = \frac{0.47\ HR.}{0.89}$

$= 0.53\ HR.$

WEIGHTED AVG. $T_{Q,DELAY}$

$= (30\%)(0.33\ HR.) + (70\%)(0.53\ HR.) = 0.47\ HR.$

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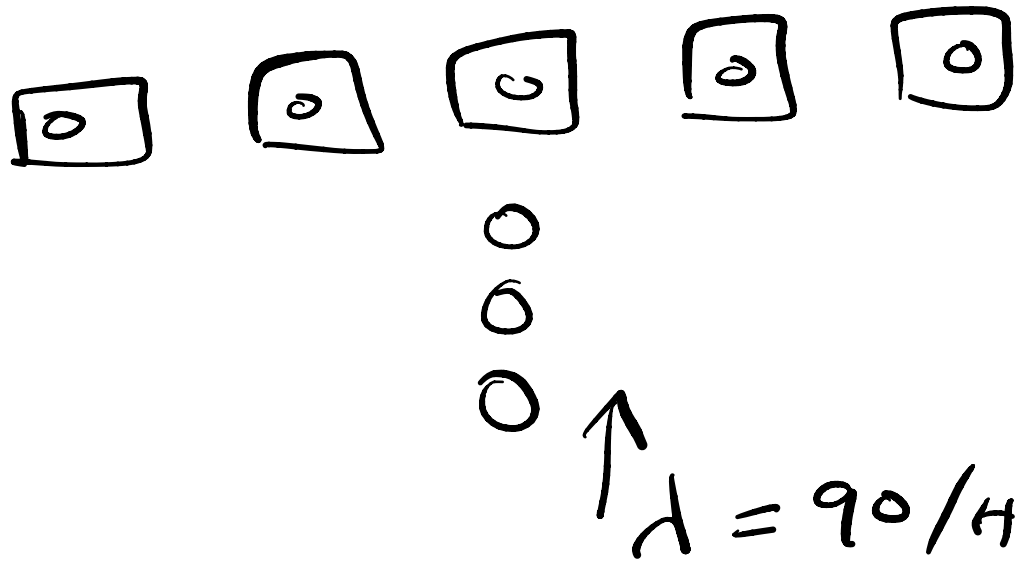
PLAN 3: SINGLE M/M/5 QUEUE



$\lambda = 90/HR.$

$\mu = \frac{60\ MIN}{3\ MIN} = 20/HR.$

$S = 5$ SERVERS

$$T_{Q,\,DELAY} = \frac{0.076\ HR.}{0.76} = 0.1\ HR.$$

∴ PLAN 3 IS BEST!

LOSS OR GOODWILL FROM AN AVERAGE GUEST WHO IS DELAYED $= (0.1\ HR.)(\$10/HR.)$
$= \$1$

BUT 90 CUSTOMERS ARRIVE PER HOUR AND SUFFER DELAY SO TOTAL LOSS OR 76%.

GOODWILL $= (\$1)(90/HR)(76\%) \approx \$68/HR.$