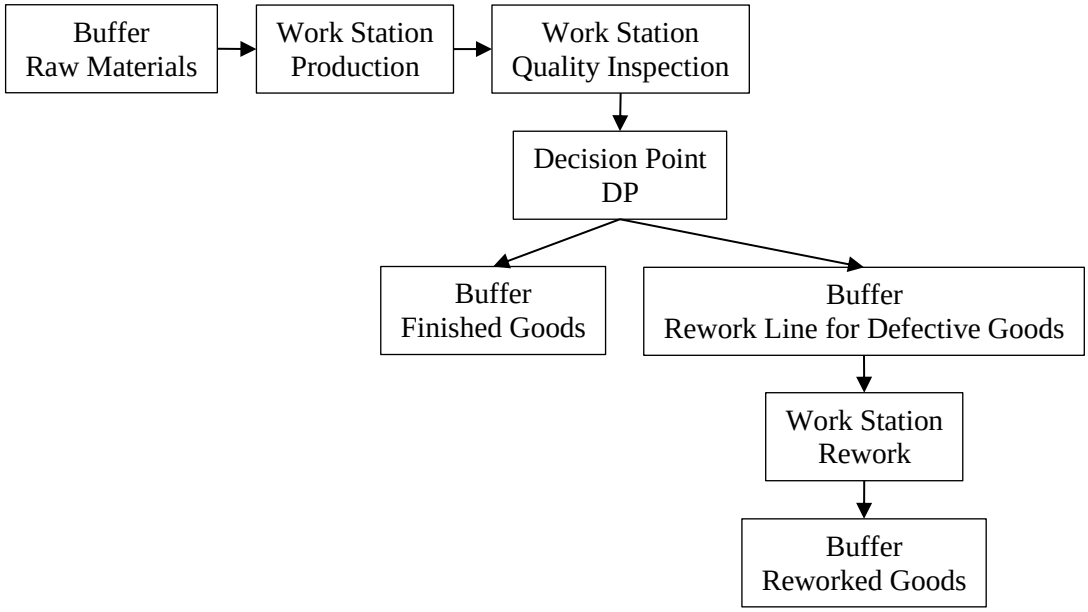
Solution to Exercises for the Midterm Exam

Questions 1, 2, 3, and 4 are based on the manufacturing problem described by the following process flow map:



We let time units denote minutes. Suppose the working time at Production can be approximated by a normal distribution with a mean of 5 minutes and a standard deviation of 1 minute. The working time at Quality Inspection can be approximated by a normal distribution with a mean of 3 minutes and a standard deviation of 1 minute. After completing the quality inspection, 5% of the products are identified as defective goods and need rework. The rest are considered finished goods. Defective goods are put in a storage area to wait for rework. The working time at Rework can be approximated by an exponential distribution with a mean of 5 minutes.

Run 50 simulations of this manufacturing process for an 8-hour working day. The initial number of raw materials is 200.

Question 1:
The following is a SimQuick model for the manufacturing problem. There are three errors in this set up. Circle the errors and correct them.

Simulation controls:			
Time units per simulation →	8 → 480		
Number of simulations →	50		
Work Stations:			
	1		
	Name →	Production	
	Working time →	Nor(5,1)	
Output destination(s) ↓	# of output objects ↓	Resource name(s) ↓	Resource # units needed ↓
Quality Inspection	1		
	2		
	Name →	Quality Inspection	
	Working time →	Nor(3,1)	
Output destination(s) ↓	# of output objects ↓	Resource name(s) ↓	Resource # units needed ↓
DP	1		
	3		
	Name →	Rework	
	Working time →	5 → Exp(5)	
Output destination(s) ↓	# of output objects ↓	Resource name(s) ↓	Resource # units needed ↓
Reworked Goods	1		

Buffers:			
1		**2**	
Name →	Raw Materials	**Name →**	Finished Goods
Capacity →	Unlimited	Capacity →	Unlimited
Initial # objects →	200	Initial # objects →	0
Output destination(s) ↓	Output group size ↓	Output destination(s) ↓	Output group size ↓
Production	1		
3		**4**	
Name →	Rework Line for Defective Goods	**Name →**	Reworked Goods
Capacity →	Unlimited	Capacity →	Unlimited
Initial # objects →	0	Initial # objects →	0
Output destination(s) ↓	Output group size ↓	Output destination(s) ↓	Output group size ↓
Rework	1		
Decision Points:			
1			
Name →	DP		
Output destinations ↓	Percents ↓		
Rework Line for Defective Goods	5		
Finished Goods	90 → 95		

After fixing the errors in SimQuick, we get the following results:

Simulation Results

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Element types	Element names	Statistics	Overall means
Work Station(s)	Production	Final status	NA
		Final inventory (int. buff.)	0.00
		Mean inventory (int. buff.)	0.01
		Mean cycle time (int. buff.)	0.05
		Work cycles started	95.12
		Fraction time working	0.99
		Fraction time blocked	0.01
	Quality Inspection	Final status	NA
		Final inventory (int. buff.)	0.00
		Mean inventory (int. buff.)	0.00
		Mean cycle time (int. buff.)	0.00
		Work cycles started	94.12
		Fraction time working	0.59
		Fraction time blocked	0.00
	Rework	Final status	NA
		Final inventory (int. buff.)	0.00
		Mean inventory (int. buff.)	0.00
		Mean cycle time (int. buff.)	0.00
		Work cycles started	4.82
		Fraction time working	0.05
		Fraction time blocked	0.00
Buffer(s)	Raw Materials	Objects leaving	95.12
		Final inventory	104.88
		Minimum inventory	104.88
		Maximum inventory	200.00
		Mean inventory	152.20
		Mean cycle time	768.42
	Finished Goods	Objects leaving	0.00
		Final inventory	88.66
		Minimum inventory	0.00
		Maximum inventory	88.66
		Mean inventory	43.76
		Mean cycle time	Infinite
	Rework Line for Defective Goods	Objects leaving	4.82
		Final inventory	0.00
		Minimum inventory	0.00
		Maximum inventory	0.14
		Mean inventory	0.00
		Mean cycle time	0.14
	Reworked Goods	Objects leaving	0.00
		Final inventory	4.80
		Minimum inventory	0.00
		Maximum inventory	4.80
		Mean inventory	2.39
		Mean cycle time	Infinite
Decision Point(s)	DP	Objects leaving	93.48
		Final inventory (int. buff.)	0.00
		Mean inventory (int. buff.)	0.00
		Mean cycle time (int. buff.)	0.00

Question 2:

This manufacturing process generates two types of goods: Finished Goods and Reworked Goods.
What's the throughput for Finished Goods? 88.66
What's the throughput for Reworked Goods? 4.80

Question 3:

In this manufacturing problem, the manufacturing process generates two types of goods: Finished Goods and Reworked Goods.

(Hint: In calculating the mean cycle time of process, we don't need to include the time spent in the first buffer "Raw Materials" or the last buffer "Finished Goods" / "Reworked Goods.")

What's the mean cycle time of process for Finished Goods? (5 + 0.05) + 3 = 8.05 minutes
What's the mean cycle time of process for Reworked Goods? (5 + 0.05) + 3 + 0.14 + 5= 13.19 minutes
What's the utilization of the Rework work station? 5 percent

Question 4:

In this manufacturing problem, we want to conduct sensitivity analysis to test the impact of varying working time at Rework (consider five scenarios with exponential distribution with a mean of 5, 10, 15, 20, and 25 minutes) on the waiting time at the Rework Line.

Revise the setup of work station Rework using ScenVar(·) and specify Scenarios below:

	Name →	Rework	
	Working time →	ScenVar(1)	
Output destination(s) ↓	# of output objects ↓	Resource name(s) ↓	Resource # units needed ↓
Reworked Goods	1		

Scenarios

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		Scenario Variables		
		1	**2**	**3**
Scenarios	**1**	Exp(5)		
	2	Exp(10)		
	3	Exp(15)		
	4	Exp(20)		
	5	Exp(25)		
	6			
	7			
	8			

Question 5:

Recall the Chery advertising example we discussed in class. The linear solution is presented below.

	A	B	C	D	E	F	G	H	I	J
1	**Advertising model**									
2				**Note:** All monetary values are in $1000s, and all exposures to ads are in millions of exposures.						
3	**Inputs**									
4	Exposures to various groups per ad									
5		**The Big Bang Theory**	**Bones**	**Gossip Girl**	**Glee**	**How I Met Your Mother**	**Modern Family**	**NCIS**	**The Office**	**Two and a Half Men**
6	channel	CBS	FOX	CW	FOX	CBS	ABC	CBS	NBC	CBS
7	Men 18-35	4.5	4.0	0.2	2.5	2.0	2.0	3.5	1.0	4.0
8	Men 36-55	2.0	3.0	0.1	1.5	1.5	1.5	3.5	2.5	3.0
9	Men >55	0.5	0.5	0.0	0.5	1.0	1.0	2.0	1.0	1.0
10	Women 18-35	4.5	1.5	1.5	3.5	2.0	2.0	2.0	1.0	3.0
11	Women 36-55	2.0	1.5	0.2	1.5	1.5	1.5	3.0	2.5	3.0
12	Women >55	0.5	0.5	0.0	0.5	1.0	1.0	2.0	1.0	1.0
13	**Viewers (millions)**	14	11	2	10	9	9	16	9	15
14										
15	**Cost per 30 sec($)**	192	108	59	127	145	130	167	191	201
16										
17	**Advertising plan**									
18		**The Big Bang Theory**	**Bones**	**Gossip Girl**	**Glee**	**How I Met Your Mother**	**Modern Family**	**NCIS**	**The Office**	**Two and a Half Men**
19	Number ads purchased	0.0	0.0	0.0	30.0	0.0	0.0	7.5	0.0	0.0
20										
21	**Constraints on numbers of exposures**									
22		Actual exposures		Required exposures						
23				by Chery						
24	Men 18-35	101.3	>=	80						
25	Men 36-55	71.3	>=	56						
26	Men >55	30.0	>=	30						
27	Women 18-35	120.0	>=	120						
28	Women 36-55	67.5	>=	56						
29	Women >55	30.0	>=	30						
30										
31	**Objective to minimize**									
32	Total cost	5,062.5								

a. The optimal total cost would (increase / decrease / remain unchanged) if cost per 30-second ads for all shows increase by 10%.
b. The optimal total cost would (increase / decrease / remain unchanged) if Chery requires 150 million exposures for the Women 18-35 group.
c. The optimal total cost would (increase / decrease / remain unchanged) if Chery requires 100 million exposures for the Men 18-35 group.
d. The optimal total cost would (increase / decrease / remain unchanged) if Chery cannot advertise on CBS.

Questions 6 and 7 are based on the furniture production problem described below.

A furniture company manufactures tables and chairs. A table requires 40 board feet of wood, and a chair requires 30 board feet of wood. Wood can be purchased at a cost of $1.50 per board foot, and 40,000 board feet of wood are available for purchase. It takes two hours of skilled labor to manufacture an unfinished table or an unfinished chair. Three more hours of skilled labor will turn an unfinished table into a finished table, and two more hours of skilled labor will turn an unfinished chair into a finished chair. A total of 5,000 hours of skilled labor is available (and *have already been paid for*). All furniture produced can be sold at the following unit prices: an unfinished table, $130; a finished table $220; an unfinished chair, $80; a finished chair, $175.

Question 6:

We would like to determine how to maximize the company's profit from manufacturing tables and chairs. The following is an incomplete Excel worksheet for this problem.
Suppose decision variables are B17:C17, B19:C19.

	A	B	C	D	E	F
1	**Manufacturing tables and chairs**					
2						
3		Table	Chair			
4	Board feet required per unit	40	30			
5						
6	Cost per board foot	1.5				
7	Labor hours per unfinished unit	2				
8						
9		Table	Chair			
10	Additional labor hours to finish	3	2			
11						
12	Selling prices	Table	Chair			
13	Unfinished	130	80			
14	Finished	220	175			
15						
16		Table	Chair	Board ft used		Available
17	Number produced			=SUMPRODUCT(B4:C4,B17:C17)		40000
18						
19	Number finished					
20	Number sold unfinished	=B17-B19	=C17-C19			
21						
22	Total labor hours used					
23						
24	Labor hours available	5000				
25						
26	Cost of wood					
27	Revenues					
28	Finished	=SUMPRODUCT(B14:C14,B19:C19)				
29	Unfinished	=SUMPRODUCT(B13:C13,B20:C20)				
30						
31	Profit					

Specify the formulas for the following three cells:
Formula for B22: =B7*SUM(B17:C17)+SUMPRODUCT(B10:C10,B19:C19)
Formula for B26: =B6*D17 or =B6*SUMPRODUCT(B4:C4,B17:C17)
Formula for B31: =SUM(B28:B29)-B26

Question 7:

Complete the Solver setup below (only need to specify the constraints):

Set Objective: B31
To: Max
By Changing Variable Cells: B17:C17,B19:C19
Subject to the Constraints:

B17:C17=integer
B19:C19=integer
B17:C17>=B19:C19
B22<=B24
D17<=F17

X Make Unconstrained Variables Non-Negative
Select a Solving Method: Simplex LP

Report the optimal solution below:

	Table	Chair
Number produced	100	1200
Number finished	0	1200

Report the optimal profit below:

Profit = 163,000