DS 601 Midterm

Instructions:

Complete all questions in the space provided and submit along with the spreadsheet with solver solutions and sensitivity reports if necessary.

Problem 1 (product mix):

A furniture company can produce beds, nightstand and dressers. The production process requires carpentry and varnishing. Each bed requires 4 hours of carpentry and 10 hours of varnishing. Each nightstand requires 6 hours of carpentry and 4 hours of varnishing. Each dresser requires 6 hours of carpentry and 5 hours of varnishing. There are 50 hours of carpentry time and 95 hours of varnishing time available. Beds generate $80 of profit, nightstand generate $60 of profit, and dressers generate $50 of profit. Demand for dressers is at least 3.

(1.1) Build an Excel spreadsheet model for this problem. Use the Excel solver to obtain the solution.

	x1	x2	x3			
Decision Variables:	**Beds**	**Nightstands**	**Dressers**			
Qty	8	0	3			
Profit	$80	$60	$50			
Objective Function:	**$790**					
Constraints:						
Carpentry	4	6	6	**50**	<=	**50**
Varnishing	10	4	5	**95**	<=	**95**
Demand for Dressers	0	0	1	**3**	>=	**3**

(1.2) What is the optimal solution and optimized Z value?

The optimal solution is 8 Beds, 0 Nightstands, and 3 Dressers. The optimized z-value to maximize profit is $790.

(1.3) Generate the Solver sensitivity report. ***Please copy and paste a screenshot below and answer the following questions:***

Microsoft Excel 16.0 Sensitivity Report
Worksheet: [Midterm_Template-2.xlsx]Product mix
Report Created: 10/17/2024 3:44:35 PM

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B3	Qty Beds	8	0	80	70	40
C3	Qty Nightstands	0	0	60	60	17
D3	Qty Dressers	3	0	50	15.45454545	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
E11	Demand for Dressers	3	-15.45454545	3	0	3
E9	Carpentry	50	6.363636364	50	88	0
E10	Varnishing	95	5.454545455	95	0	58.66666667

a) Suppose that a **bed** can generate $20 of profit, will the optimal solution change, and why?

Yes, the Optimal Solution would change. Looking at the sensitivity report we can note that the objective coefficient for Beds, $80, has an allowable decrease of only $40. This means the Profit for Beds cannot go below $40. Thus, a drop to $20 would require us to adjust the model giving a different optimal solution.

b) Suppose that there are 10 more hours of **carpentry** available, how the objective function would change, and why?

An additional 10 hours of carpentry would increase our objective function by about $63.60. This is because the shadow price per additional hour of Carpentry is $6.36, multiplying this by 10 gives us the expected increase in Profit accumulated. Also, we are allowed 88 additional hours of Carpentry, so the 10 hour increase fits within our range of optimality

c) If the additional 10 more hours of **carpentry** requires a cost of $10 per hour, is it worth for the company to acquire?

No, it would not be worth it. This is because the $10 of additional cost exceeds our $6.36 of additional profit, ultimately incurring an additional cost of $36.40.

d) Suppose that there are 10 more hours of **varnishing** available, how the objective function would change, and why?

The objective function would not change since the Varnishing constraint in the sensitivity report is not allowed to take on any additional hours within our Range of Optimality. Therefore, our objective function will stay at $790

e) Suppose that the minimum quantity for **dressers** is removed, how the objective function would change, and why?

If the minimum quantity of dressers is removed the objective function would increase by $46.36. This is because the shadow price for Dressers is -$15.46 and has an allowable decrease of 3. Meaning that removing the dressers requirement and cutting the 3 dressers will yield us an additional $46.36 to our objective.

Problem 2 (investment):

A trust fund manager has $1,000,000 to invest in the following collection of bonds to maximize the annual return.

Bond	Annual Return	Maturity	Risk
A	9.5%	Long	High
B	8.5%	Short	Low
C	9.0%	Long	Low
D	8.2%	Short	High

The manger wants to invest no more than 35% of total asset in any one bond, and no more than 40% of total asset in the short-term bond, and no more than 50% of total asset in the high-risk bond.

(2.1) Build an Excel spreadsheet model for this problem. Use the Excel solver to obtain the solution.

	A	B	C	D			
Decision Variables:	350000	300000	350000	0			
Annual Return	9.50%	8.50%	9.00%	8.20%			
Maturity	Long	Short	Long	Short			
Risk	High	Low	Low	High			
Objective Function:							
90250	9.03%						
Constraints:							
Amount	1	1	1	1	1000000	<=	$ 1,000,000.00
35%	1				350000	<=	$350,000.00
		1			300000	<=	$350,000.00
			1		350000	<=	$350,000.00
				1	0	<=	$350,000.00
40% ST	0	1	0	1	300000	<=	$400,000.00
50% High Risk	1	0	0	1	350000	<=	$500,000.00

(2.2) What is the optimal solution and optimized Z value?

The Optimal Solutions are $350,000 into Bond A, $300,000 into Bond B, and $350,000 into Bond C, with no money invested into Bond D. The optimized Z-Value to maximize return is $90,250 or a yield of 9.03%

(2.3) Generate the Solver sensitivity report. ***Please copy and paste a screenshot below and answer the following questions:***

Microsoft Excel 16.0 Sensitivity Report
Worksheet: [Midterm_Template-2.xlsx]Investment
Report Created: 10/17/2024 4:25:42 PM

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B3	Decision Variables: A	350000	0	0.095	1E+30	0.01
C3	Decision Variables: B	300000	0	0.085	0.005	0.003
D3	Decision Variables: C	350000	0	0.09	1E+30	0.005
E3	Decision Variables: D	0	-0.003	0.082	0.003	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
F10	Amount	1000000	0.085	1000000	50000	300000
F11		350000	0.01	350000	150000	50000
F12		300000	0	350000	1E+30	50000
F13		350000	0.005	350000	300000	50000
F14		0	0	350000	1E+30	350000
F15	40% ST	300000	0	400000	1E+30	100000
F16	50% High Risk	350000	0	500000	1E+30	150000

a) Is there any fund(s) have NO investments? If yes, how much annual return would this/these Bond(s) have to generate before the manager may consider investing in it? Why?

Bond D has no investments, and to even consider investing into Bond D it must generate an 8.5% return. This increase is attributed to the -0.003 reduced cost value in the sensitivity report on decision variable D. This negative value means that Bond D's return is 0.003 below the optimal amount to begin investing in and must increase by 0.003, which in this case is 0.3%

b) If $200,000 **more** is allowed to be invested in **short-term** bonds, will the annual return increase or decrease and by how much? Why?

If $200,000 more were allowed to be invested in Short-term bonds, the annual return wouldn't be affected as the Allowable increase is infinite and has a shadow price of 0. This means even if we allowed an additional $200,000 to be invested, it wouldn't change the amount we already have invested. This is apparent in the solver output as the objective is satisfied at $300,000 which is below our limit of $400,000. Thus, the return objective would remain at 9.03%.

c) If $200,000 **less** is allowed to be invested in **high-risk** bonds, will the annual return increase or decrease and by how much? Why?

If $200,000 less is allowed to be invested in High-Risk, our annual return will decrease. Since the allowable decrease for the High-risk constraint is only $150,000, exceeding this would change our objective. Taking away this extra $50,000 takes away from the higher returns of 9.5% and requires us to invest it in some other lower-yielding Bond, ultimately dragging the returns down to 8.98%, or 0.05% below the optimal solution.

d) What's the value of having $200,000 more total investment? Please explain.

The value of having $200,000 more of a total investment means to yield a higher dollar amount but not any additional return. This is because we will be investing more into each respective Bond. For instance, with a total amount of $1,000,000 we will yield a total amount of $90,250, or 9.03%. With a new total amount of $1,200,000, we will yield a total amount of $108,300, but still 9.03%. Therefore, an additional $200,000 invested will gain us an additional value to our objective by $18,050.

Problem 3 (inventory):

A manufacture is planning he production of a new model of coffee machine for the next few months. The expected demand along with the expected production costs and the expected capacity for production are given in the following table.

Month	1	2	3	4	5	6
Demand	300	350	280	450	400	480
Production Cost	$100	$110	$120	$90	$100	$85
Production Capacity	450	450	450	450	450	450

Currently, they have 200 units in inventory on hand. The manufacturer wants to produce at least 300 units per month to smooth production and maintain a level workforce. The company also wants to maintain a safety stock of at least 30 units at the end of each month. The manufacturer estimates that the inventory holding cost is 10% of the production cost per month for each unit (hint: make sure to use average inventory). Management wants to determine how many units of this coffee machine to manufacture during each of the next 6 months to meet the expected demand at the lowest possible total cost.

(3.1) Build an Excel spreadsheet model for this problem. Use the Excel solver to obtain the solution.

Month	1	2	3	4	5	6	
Beginning Inventory (B)	**200**	200	150	170	160	60	30
Units Produced (P)	300	300	300	440	300	450	
Units Demanded (D)	300	350	280	450	400	480	
Ending Inventory	200	150	170	160	60	30	
Minmum Produciton	300	300	300	300	300	300	
Maximum Production	450	450	450	450	450	450	
Minimum Inventory (safety stock)	30	30	30	30	30	30	
Unit Production Cost	$100	$110	$120	$90	$100	$85	
Unit Carrying Cost	$10.00	$11.00	$12.00	$9.00	$10.00	$8.50	
Monthly Production Cost	$30,000	$33,000	$36,000	$39,600	$30,000	$38,250	
Monthly Carrying Cost	$2,000	$1,925	$1,920	$1,485	$1,100	$383	
Objective Function:	$215,663						

(3.2) What is the optimal solution and optimized Z value?

The optimal solutions of Production for months 1 through 6 are: 300, 300, 300, 440, 300, and 450 respectively. The optimally minimized z-value is $215,663.

(3.3) How much money would they save if they were willing to drop the restriction about producing at least 300 units per month?

If they removed the minimum production requirement, the company would optimize their cost to $209,793. This would save them $5,870 of additional cost incurred

(3.4) How much money would they save if safety stock were not required?

If the company were to eliminate the safety stock requirement, they would optimize their cost to $212,273. This would save them $3,390 of additional cost incurred.

DS 601

Problem 4 (transportation):

A company has two plants producing a certain product that is to be shipped to three distribution centers. The unit production costs are the same at both plants, and the s hipping cost (in hundreds of dollars) per unit of the product is shown for each combination of plant and distribution center as follows:

	Distribution Center		
	D	**E**	**F**
Plant A	8	7	4
Plant B	6	8	5

A total of 120 units is to be produced and shipped per week. Each plant can produce and ship any amount up to a maximum of 70 units per week, so there is considerable flexibility on how to divide the total production between the two plants so as to reduce shipping costs. Assume that each distribution center must receive at least 40 units per week.

(4.1) Build an Excel spreadsheet model for this problem. Use the Excel solver to obtain the solution.

Decision Variables:			
	DC		
Plant	D	E	F
A	0	30	40
B	40	10	0
Total Received			
Capacity			
Cost	**DC**		
Plant	D	E	F
A	8	7	4
B	6	8	5
Objective Function:	690		

(4.2) What is the optimal solution and optimized Z value?

The optimal solution is 0 from Plant A and 40 from Plant B for Distribution center D, 30 from Plant A and 10 from Plant B for Distribution center E, and 40 from Plant A and 0 from Plant B for Distribution center F. The minimal cost optimized Z-value is $690,000

(4.3) Is there any route that doesn't have any shipments? Does it make sense, and why?

Yes, At Distribution center F it would make sense to ship the max of 40 units from Plant A since it is the lowest cost ($4) and none should be shipped from Plant B ($5). At Distribution Center D, the next lowest

cost comes from Plant B ($5), so it makes sense to ship the max of 40 units rather than Plant A ($8). If we increased the max Plant Capacity to 80, we could max out Distribution Center E at 40 units from Plant A ($7) and zero from Plant B since it is a lower cost than Plant B ($8). However, since we reached the max capacity shipped from Plant A in this scenario, the remaining 10 units must be shipped from Plant B.

The End of the Exam.