

EM384: Analytical Methods for Engineering Management

Lesson 15: Mixed Problems

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Lesson Objectives

Lesson 15 Objectives

- Understand and recognize mixed problems.
- Formulate mixed algebraically.
- Solve mixed problems using Excel Solver.

Mixed Problems

Linear programming problems that don't fit in the resource allocation or cost-benefit trade-off categories.

Identifying feature: **requirement constraints and limiting constraints**

- Different types of constraints (\leq , \geq , $=$)
- Objective: Maximize or Minimize

In-class exercise

Model and solve the following Linear Program in Excel (You may omit the Parameters part of the model):

Decision variables:

$$x_1, x_2, y_1$$

Objective function:

$$\text{Maximize } Z = 10x_1 + 5x_2 - 10y_1$$

Constraints:

$$y_1 + 10 = 2x_1 - x_2$$

$$3x_2 - x_1 \geq 35$$

$$x_1 + x_2 + y_1 \leq 82$$

$$x_1, x_2 \geq 0$$

Excel Solution

	A	B	C	D	E	F
1	Decision Variables					
2						
3	x1	x2	y1			
4	68.33333	0	13.66667			
5						
6	Objective Function			Maximize	546.6667	
7						
8	Constraints					
9						
10	x1	x2	y1	LHS		RHS
11	0	0	10	136.6667	=	136.6667
12	0	-1	3	41	>=	35
13	1	1	1	82	<=	82

Practical Exercise

You are a consultant for the Super Grain Corporation, and your boss has asked you to help develop the advertising campaign strategy for the promotion campaign for Crunchy Start cereal. The three most effective advertising media for this product are:

- Television commercials on Saturday morning programs for children.
- Advertisements in food and family-oriented magazines.
- Advertisements in Sunday supplements of major newspapers.

The limited resources in the problem are:

- Advertising budget (\$4 million).
- Planning budget (\$1 million).
- TV commercial spots available (5).

Additional parameters are on the PE handout and the objective will be measured in terms of maximizing the expected number of exposures.

1. Formulate your linear program algebraically.
2. Design an Excel model to solve your linear program.

Problem Formulation

Decision variables:

x_1 : Number of Television commercials on Saturday morning programs for children.

x_2 : Advertisements in food and family-oriented magazines.

x_3 : Advertisements in Sunday supplements of major newspapers.

Objective function:

Maximize $Z = 1300x_1 + 600x_2 + 500x_3$ (Exposure in 1000s)

Constraints:

$300x_1 + 150x_2 + 100x_3 \leq 4000$ (Advertising budget in 1000s)

$90x_1 + 30x_2 + 40x_3 \leq 1000$ (Planning budget in 1000s)

$x_1 \leq 5$ (TV commercial spots available) $x_1, x_2, x_3 \geq 0$ (non-negativity)

Excel Solution

	A	B	C	D	E	F	G	H	I
1	Parameters								
2			TV	Magazine	Sunday				
3		Ad Budget	300	150	100	(\$1000s)			
4		Planning Budget	90	30	40	(\$1000s)			
5		# Exposures	1300	600	500	(1000s)			
6									
7	Decision Variables								
8			TV	Magazine	Sunday				
9		# Ads	0	20	10				
10									
11	Objective Function								
12		Max. # Exposures	17,000	(1000s)					
13									
14	Constraints								
15			TV	Magazine	Sunday	LHS		RHS	
16		Ad Budget	300	150	100	4000	<=	4000	(\$1000s)
17		Planning Budget	90	30	40	1000	<=	1000	(\$1000s)
18		# TV Ads	1	0	0	0	<=	5	
19									

Revised Problem Formulation

Decision variables:

x_1 : Number of Television commercials on Saturday morning programs for children.

x_2 : Advertisements in food and family-oriented magazines.

x_3 : Advertisements in Sunday supplements of major newspapers.

Objective function:

Maximize $Z = 1300x_1 + 600x_2 + 500x_3$ (Exposure in 1000s)

Constraints:

$300x_1 + 150x_2 + 100x_3 \leq 4000$ (Advertising budget in 1000s)

$90x_1 + 30x_2 + 40x_3 \leq 1000$ (Planning budget in 1000s)

$x_1 \leq 5$ (TV commercial spots available)

$1.2x_1 + 0.1x_2 \geq 5$ (Young Children, in millions)

$0.5x_1 + 0.2x_2 + 0.2x_3 \geq 5$ (Parents, in millions)

$40x_2 + 120x_3 = 1490$ (Coupon redemption, in 1000s)

$x_1, x_2, x_3 \geq 0$ (non-negativity)

Excel Solution

	A	B	C	D	E	F	G	H	I
1	Parameters								
2			TV	Magazine	Sunday				
3		Ad Budget	300	150	100	(\$1000s)			
4		Planning Budget	90	30	40	(\$1000s)			
5		Young Children	1.2	0.1	0	(Millions)			
6		Parents	0.5	0.2	0.2	(Millions)			
7		Coupon Redemption	0	40	120	(\$1000s)			
8		# Exposures	1300	600	500	(1000s)			
9									
10	Decision Variables								
11			TV	Magazine	Sunday				
12		# Ads	3	14	7.75				
13									
14	Objective Function								
15		Max. # Exposures	16,175	(1000s)					
16									
17	Constraints								
18			TV	Magazine	Sunday	LHS		RHS	
19		Ad Budget	300	150	100	3775	<=	4000	(\$1000s)
20		Planning Budget	90	30	40	1000	<=	1000	(\$1000s)
21		# TV Ads	1	0	0	3	<=	5	
22		Young Children	1.2	0.1	0	5	>=	5	(Millions)
23		Parents	0.5	0.2	0.2	5.85	>=	5	(Millions)
24		Coupon Redemption	0	40	120	1490	=	1490	(\$1000s)

Conclusion

Homework:

- work on Homework Set 5
- Read Chapter 7.3

Next Lesson:

- Create and interpret Sensitivity Reports, to include:
 - Shadow Price
 - Reduced Cost
 - Constraint outcomes: binding and nonbinding