Summary

Model	Optimal Utility	Optimal Course Selection
Basic	46	**Bid on A, E, F, G, H, I, J**
Additional Constraints	44	**Bid on A, C, E, F, G, H, J**
Synergy Effect	47	**Bid on A, C, E, G, I, J (+ certificate)**
Exclude previous optimal solution	46	**Bid on B, C, E, G, H, I, J (+ certificate)**

Excluding Solutions

This approach can be used to exclude any number of previously-found solutions, by adding a constraint for each solution you want to exclude

Excluding Two Solutions

- We want to exclude **A, C, E, G, I, J** <u>and</u> **B, C, E, G, H, I, J**

- To eliminate **A, C, E, G, I, J** we already have this in our model:

$$y_A + y_C + y_E + y_G + y_I + y_J + (1 - y_B) + (1 - y_D) + (1 - y_F) + (1 - y_H) \leq 9$$

- What constraint should we add to eliminate **B, C, E, G, H, I, J** ?

Excluding Two Solutions

- We want to exclude **A, C, E, G, I, J** <u>and</u> **B, C, E, G, H, I, J**

- To eliminate **A, C, E, G, I, J** we already have this in our model:

$$y_A + y_C + y_E + y_G + y_I + y_J + (1 - y_B) + (1 - y_D) + (1 - y_F) + (1 - y_H) \leq 9$$

- What constraint should we add to eliminate **B, C, E, G, H, I, J** ?

$$y_B + y_C + y_E + y_G + yH + y_I + y_J + (1 - y_A) + (1 - y_D) + (1 - y_F) \leq 9$$

Updated Excel Solution

Bid on A, C, F, G, I, J

DECISIONS	A	B	C	D	E	F	G	H	I	J	Z
Course	1.0	0.0	1.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0	1.0

OBJECTIVE

Total utility	46

CONSTRAINTS

	LHS		RHS
Points budget	780	<=	1,000
Course credit maximum	51	<=	54
Course credit minimum	51	>=	36
Mon, Wed H3 classes	2	<=	3
Tue, Thr H3 classes	2	<=	3
Mon, Wed H4 classes	3	<=	3
Tue, Thr H4 classes	3	<=	3
Do not take A and B	1.0	<=	1
Take either B or C	1.0	>=	1
H requires E	0.0	<=	0
If I not chosen, Z is 0	1.0	<=	1
If J not chosen, Z is 0	1.0	<=	1
If either I or J is chosen, Z is 1	1.0	>=	1
Exclude previous optimal solution	4.0	<=	5
Exclude 2nd optimal solution	2.0	<=	6
Binary constraints			

Summary

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Synergy Effect	47	**Bid on A, C, E, G, I, J (+ certificate)**
Exclude previous optimal solution	46	**Bid on B, C, E, G, H, I, J. (+ certificate)**
Excluding two solutions	46	**Bid on A, C, F, G, I, J (+ certificate)**

Note that the optimal value didn't decrease when we excluded the second optimal solution

Recap: The Power of Binary Variables

- Binary variables:
  - Are very useful to model business decisions that involve doing something or not doing something (as opposed to how much of something to do) …
  - … but make solving an optimization model more challenging

- Binary variables allow us to model IF-THEN relationships and non-linearities s using “tricks” so that the formulation remains linear.

- A vast array of real-world decision problems can be modeled with binary variables

A Sample of Optimization Applications I have Worked On

- Airline/Airport Operations
  - Fleet Assignment, Crew Assignment, Gate Assignment, Staff Scheduling
- “Last Mile” Delivery and Routing
- Retail Pricing and Promotions
- Supply Chain Inventory Allocation

What's Next

- *Wednesday*: Discrete Optimization – Part 2 (Application to Supply Chain Optimization)

- *Thursday*: Deliverable #7 due

- *Friday*: Recitation on Discrete Optimization

- 1-on-1 Meetings
  - *Please book via https://calendly.com/ramamit*
  - *I have added more Calendly slots. If the Calendly times don't work, please email my assistant Laura (brentrup@mit.edu) to find a time.*

APPENDIX
Optional How Integer Optimization Problems Are Solved in Practice