2105623 Optimization of Chemical Processes

Department of Chemical Engineering, Chulalongkorn University

Week 5 activity sheet

Modeling IV: logical and discrete decisions | Monday 7 September 2026

Keep this sheet in front of you all session. The three activities are written out here in full, so you do not have to read them off the screen. Work on this sheet; hand back what each activity asks for.

Activity 1 — logic to linear — 20 min · pairs, paper then board

Translate all eight English statements into **linear** constraints in binary variables.

Use z_A, z_B, z_C, z_D for the units, z_1, z_2, z_3 for the technologies, u_C for the run rate of unit C, and z_W for the warehouse lease. **No products of binaries are permitted.**

1. If unit A is built, unit B must also be built.
2. At most two of the four units may be built.
3. Exactly one of the three technologies must be chosen.
4. If unit A is built, unit B must *not* be built.
5. Unit C runs at a rate of at least 20 t per day, or it does not run at all.
6. If total production exceeds 100 t, the second warehouse must be leased.
7. Unit D may be built only if *both* A and B are built.
8. At least one of A, B, C must be built, and if all three are built a supervisor must be hired.

At 12 minutes, eight pairs are called to the board, one statement each.

Hand back: one sheet per pair, all eight translations.

Activity 2 — big-M roulette — 25 min · groups of 3 to 4, computer

Every group solves the **same** model, in `w05-fixed-charge.xlsx`. Complete the yellow cells. Then set `Model!$C$36` to **your group's value of** M from the table below, and record three numbers.

(1) the **LP relaxation** objective — replace the `bin` constraint on `$H$40:$H$45` by ≤ 1 and re-solve;

(2) the **integer optimum**, with `bin` restored;

(3) the **solve time** reported by OpenSolver.

Before you solve, predict: which of the three columns will differ between groups, and which will be the same for everyone? Write your prediction down. Being wrong about it is the point of the activity.

Group	multiple	M, t/yr	LP bound	integer opt.	time, s
1	$M^\star$, tightest	2 232			
2	$2M^\star$	4 464			
3	$10M^\star$	22 320			
4	$10^3 M^\star$	2.232×10^6			
5	$10^6 M^\star$	2.232×10^9			

Fill in your own row, then copy the whole table from the board as the other groups call theirs out.

Hand back: three numbers per group, called out for the board table.

Activity 3 — tighten it

20 min · groups of 3 to 4, paper

Each constraint below is written with a lazy $M = 10^6$. For each one, derive the **tightest valid** M and give the one-line argument — an upper bound on the left-hand side over the rest of the feasible set.

One of the three has no finite valid M. Identify which, and say what has to be added to the model before a big-M formulation is legitimate at all.

(a) Zinc-air plant, on/off link for the slot-die coater U3

$$x_{\text{U3,cath}} + x_{\text{U3,sep}} \;\le\; M\, z_{\text{U3}}$$

U3 has 3 600 h/yr, makes cathode sheet at 0.62 t/h and separator film at 0.48 t/h, and separator demand is 1 500 t/yr.

(b) Refinery blend — the second tank-farm bay is leased only above 8,000 t of throughput

$$\textstyle\sum_c u_c \;\le\; 8\,000 + M\, z_{\text{lease}}$$

Availabilities total 12 700 t; the two grade volume windows are $[4000, 7000]$ and $[2500, 5000]$ t; the octane, vapour pressure and sulfur specifications also apply.

(c) Rented external storage, usable only if the third-party contract is signed

$$R_t \;\le\; M\, y_{\text{contract}}, \qquad R_t \ge 0 \text{ (t)}$$

R_t appears in $I_t \le W + R_t$ and in the objective at 450 USD per tonne-month. It carries no upper bound anywhere in the model.

Hand back: three values of M, one sentence of justification each, one sheet per group.

What is due. Homework 2 is due in Week 6. It covers Weeks 4 to 6 and includes the model-audit task, which is the part people leave to the last day. The Week 5 notebook has all seven sections: `w05-modeling4-logical-discrete.ipynb`.