[Report title: name the system and the decision]

Group [NN] | [Topic T# or self-proposed]

[Member 1, ID] [Member 2, ID] [Member 3, ID]

2105623 Optimization of Chemical Processes, Semester 1/2026

Submitted [date]

A title states the system and the decision, for example "Minimum-cost dispatch of a 500 kWh battery under the MEA time-of-use tariff". "Optimization project" is not acceptable. No abstract: the four-page limit is better spent on Sections 2, 5 and 6.

1 Problem statement and scope

About half a page, 200 to 250 words. State the physical system, the decision maker and the decision to be made, and why it is not obvious: what is scarce, what competes with what. Give the time horizon and the physical boundary. State explicitly what you exclude and why, for example "capital cost is treated as sunk, so the model optimizes operation only". From this section alone a reader must be able to tell what question the numbers in Section 5 answer. No equations here, and no extended literature review: one or two references showing the problem is real are enough. This section is the "scope and decision" part of the Week 6 specification template, written for a reader. Scored under rubric row R1.

2 Mathematical formulation

About one page, in the course notation: decision vector x, objective $f(x)$, inequality constraints $g(x) \leq 0$, equality constraints $h(x) = 0$. This section is the algebraic form of the structured specification you submitted in Week 6, so keep its order: sets, parameters, variables, objective, constraints. Every symbol must appear in the nomenclature table with units, every variable carries a domain and bounds, and every constraint block needs a name, a one-line statement in words, and one sentence of justification. The numbered statements in words are what Section 5 audits the solution against, so do not drop them. State any assumption the algebra hides. Close with one sentence naming the model class and the reason, for example "an MILP, because the build decisions are binary and all other relations are linear".

Sets and indices

One line per set: $i \in \mathcal{I}$, description, cardinality in the instance solved.

Parameters

One line per parameter: symbol, description, units. Values go in Section 3, not here.

Decision variables

One line per variable: symbol, description, units, domain (continuous, integer, binary), bounds. State which variables are the real decision and which are auxiliary.

Model

$$
\begin{aligned}
\min_{x} \quad & f(x) = [\textbf{objective expression}] && && (1)\\
\text{s.t.} \quad & g_j(x) \le 0, && j = 1, \dots, m && (2)\\
& h_k(x) = 0, && k = 1, \dots, p && (3)\\
& x^{\mathrm{L}} \le x \le x^{\mathrm{U}}, \quad x_b \in \{0,1\} \ \ \forall b \in \mathcal{B} && && (4)
\end{aligned}
$$

Replace (1) to (4) with your actual model, one numbered equation per constraint block, indexed over the relevant sets. Refer to each equation by number in the text. ***Model class:*** *[LP / MILP / NLP / MINLP / two-stage stochastic], because [reason].*

3 Data and assumptions

About half a page. Every parameter value, its units, and where it came from: a citation, a measurement, or the rule used to synthesize it. Synthesized data are acceptable, but state the generating rule and the plausibility argument ("changeover time drawn as 4 to 8 h, consistent with clean-in-place practice"). List the assumptions that materially change the answer: constant efficiency, perfect foresight, linear blending, steady state. A grader must be able to rebuild your data file from this section.

Table 1: Model parameters, values, units and sources. Replace all placeholder rows.

Symbol	**Description**	**Value and units**	**Source**
c_i	[unit cost of component i]	[12.4 to 31.0 THB/kg]	[ref. or synthesis rule]
D_t	[demand in period t]	[see Appendix A]	[ref. or synthesis rule]
η	[round-trip efficiency]	[0.92, dimensionless]	[ref. or synthesis rule]

4 Solution approach

About half a page. State the modeling environment and version (for example Pyomo 6.7), the solver and version, and the algorithm class it uses (simplex, branch and bound, interior point, SQP). Report model size: continuous variables, binary or integer variables, constraints, before and after presolve if available. State termination criteria (gap and feasibility tolerances, iteration or time limit), the starting point or multistart scheme for a nonconvex problem, and wall-clock run time on stated hardware. Describe any reformulation (piecewise linearization, big-M, epsilon-constraint, profile discretization) and how you chose its constants.

5 Results and model verification

About one page, and the section a grader reads first. Part one, the result: give the optimal objective value with units and a sensible number of significant figures, the termination status and the final optimality gap. Put the solution in a table, not in prose. Do not claim global optimality for a nonconvex problem solved by a local solver. Part two, the verification: report the model test suite of deliverable D3 in Table 2, with at least three degenerate instances whose expected answers are closed forms derived by hand, one monotonicity check, and the units audit.

State the closed form for each degenerate instance in the table, not just the number, and say how the expected value was computed without building the model under test. Report any test that failed, what it revealed and what you changed. A suite in which nothing ever failed is a suite that was written after the fact, and graders read it that way. Add one independent check beyond the suite (hand calculation on a reduced instance, a second solver, or a bound) for rubric row R4.

Table 2: Model test suite. Replace all placeholder rows. Expected values are computed by arithmetic that does not construct the model under test.

Test	**Instance and closed form**	**Expected / obtained**	**Result**
Degenerate 1	[zero demand: $f^* = hI_0\lvert\mathcal{T}\rvert\Delta t$]	[value / value]	[pass, tol. 1e-6]
Degenerate 2	[single period, ample capacity]	[value / value]	[pass]
Degenerate 3	[one unlimited resource]	[value / value]	[pass]
Monotonicity	[capacity swept over 50 to 150 percent, f^* nonincreasing]	[11 points]	[pass]
Units audit	[every constraint and objective term]	[24 expressions]	[pass]

Table 3: Optimal solution and verification summary. Replace all placeholder rows.

Quantity	**Symbol**	**Optimal value**	**Units / note**
Objective	$f(x^*)$	[value]	[THB/y, kW, kg/h, . . .]
[Key decision 1]	x_1^*	[value]	[units]
[Key decision 2]	x_2^*	[value]	[units]
Solver status	n/a	[optimal / feasible]	[termination condition]
Optimality gap	n/a	[0.00 percent]	[MILP only]
Independent check	n/a	[agrees to 0.3 percent]	[describe the check]

6 Sensitivity and interpretation

About three quarters of a page, and the section that separates a good report from an average one. For an LP, report shadow prices and reduced costs with units and their validity ranges, and say which constraints are active. For an MILP, report a parametric sweep or scenario comparison, since dual information is not valid across integer changes. For an NLP, report the multipliers λ (equality) and μ (inequality) and confirm the sign convention. Include at least one trade-off curve or scenario table. Then answer the engineering question: what should the decision maker change, by how much, what is it worth, and where does the conclusion stop holding?

7 Conclusions and limitations

About a quarter page, 100 to 120 words. Three or four sentences of conclusion tied to numbers already reported, then the limitations a reader needs before using the result: data quality, excluded

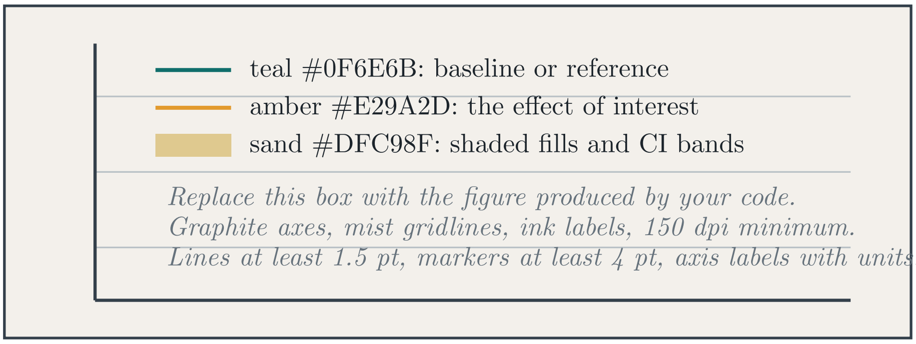

Figure 1: [State what the figure shows and what the reader should conclude.] Figures use the Teal-Amber Lab Palette v1.0 in the categorical order teal, amber, rust, skyblue, sage, plum, graphite, sand. Encode ordered or continuous data with a sequential ramp, never categorical colors, and center a diverging ramp on zero. Every figure must stay readable in grayscale and be referenced from the text, as Figure 1 is here.

physics, the gap between the modeled and the real decision, and the instance size the approach scales to. No new results here.

8 AI use and verification disclosure

Outside the four-page limit and mandatory, graded under rubric row R3. Using an AI assistant to draft the specification, the Pyomo code, the test code, the figures or the prose is permitted and expected in this course. What is graded is the evidence that the result is correct. Fill the table below with one row per artifact the assistant touched: name the tool and version, say exactly what it produced (a named constraint, a data-synthesis script, a figure, a paragraph), and name the test in Table 2, or the manual check, that validates it. Every generated artifact needs a check that could have failed. An entry reading "reviewed by the group" with nothing attached is not a check. A general statement such as "AI was used for coding help" does not meet the requirement, and a model drafted with AI assistance and submitted without the test suite scores zero on rubric row R2 regardless of the numbers it reports. If no AI tool was used, write one sentence saying so and delete the table.

Table 4: AI use and the verification attached to it. Replace all placeholder rows.

Tool and version	**What it drafted or edited**	**How it was validated**
[tool, version]	[first draft of `inventory_balance` and `capacity` rules]	[degenerate tests 1 and 2, plus units audit; sign error in the balance found and corrected]
[tool, version]	[data synthesis script for D_t]	[totals and ranges checked against the cited source; regenerated with a fixed seed]
[tool, version]	[language editing of Sections 1 and 6]	[read and corrected by the group; no technical content changed]

Then two or three sentences in prose: which parts of the work were drafted by a tool and *which were written from scratch, what the tool got wrong, and how you found it. This is the paragraph that distinguishes a group that used the assistant well from a group that trusted it.*

References

Outside the four-page limit. Cite every data source, every formulation you adapted and every piece of external code. Textbook citations follow the house form, for example "Rao, Ch. 7". A numbered or an author-year style is acceptable; consistency matters more than the choice.

[1] S. S. Rao, *Engineering Optimization: Theory and Practice*, 4th ed., Wiley, 2009, Ch. [N].

[2] T. F. Edgar, D. M. Himmelblau, L. S. Lasdon, *Optimization of Chemical Processes*, 2nd ed., McGraw-Hill, 2001.

[3] [Author], [Title], [Journal or agency], [year]. [Data source used for Table 1.]

Nomenclature

Outside the four-page limit, mandatory, graded under rubric row R6. Every symbol appearing anywhere in the report is listed once with units, in SI or the industrial unit a practitioner expects. Group as sets, parameters, variables, Greek symbols, acronyms, alphabetical within each group.

Symbol	**Description**	**Units**
Sets and indices		
$\mathcal{I}$, i	[set of components, index]	n/a
$\mathcal{T}$, t	[set of time periods, index]	n/a
Parameters		
c_i	[unit cost of component i]	[THB/kg]
D_t	[demand in period t]	[kg]
Decision variables		
x_{it}	[flow of component i in period t]	[kg]
y_i	[1 if site i is built, 0 otherwise]	[binary]
Greek symbols		
η	[round-trip efficiency]	[dimensionless]
λ, μ	[Lagrange multipliers, equality and inequality constraints]	[THB per unit]
Acronyms		
MILP	Mixed-integer linear program	n/a

Appendix A. Supporting material (optional, two pages maximum)

Outside the four-page limit. Use it for full data tables, derivations, extra scenario results and solver logs. It is read at the grader's discretion, so no result the main text depends on may live here alone, and it may not evade the limit on Sections 1 to 7.

Submission checklist. Sections 1 to 7 within four pages; Section 8 present and complete; every figure and table captioned and referenced; every symbol in the nomenclature with units; every data value sourced; solver status and gap reported; the test suite of D3 reported in Table 2 with three degenerate instances, a monotonicity check and a units audit, and the suite itself submitted with the code; one independent check beyond the suite described; figures in the Teal-Amber Lab Palette, readable in grayscale; all gray guidance text deleted.