TCLab Project

The TCLab Project exercises principles of *modeling*, *estimation*, and *control* and requires effective communication skills to convey results and deliver insights.

Problem statement: **Course TCLab activities** use one heater. Extend the concepts of modeling, regression, and control to derive a physics-based model of a two-heater system. Show how this first principles model compares to an empirical model. Use engineering insight to discuss fundamental factors that affect performance. Some questions to discuss may include:

1. Is radiative heat transfer significant?
2. Is the temperature response first order or second order?
3. What disturbances affect the system?
4. What physics-based parameters are uncertain and can be adjusted to match data?
5. What controller tuning parameters are best?
6. What controller performance criteria are used to judge best performance?

A rubric for the project report follows on the next page:

TCLab Report Grading Sheet

Name_____Date_____Score_____**/100**

	Max	Score	Comments
Organization that includes appropriate headings	5		**Abstract** (1 paragraph overview) **Introduction** (Objective, methods, apparatus) **Theory** (models, parameter regression, controller design) **Results and Discussion** (model discussion, comparison of 1st principles / empirical models, controller tuning) **Conclusion** (summarize main results)
Quality of communication – clarity, precision, conciseness, spelling, grammar	5		Avoid switching between 1st and 3rd person. Concise: 2 pages max for report (this is a big challenge). Include appendix with source code for modeling, parameter estimation, and controller. Appendix may also include additional details to support the report but should not include the raw data. Check for spelling or grammatical errors. It is a good idea to read the report out loud once before submitting.
Clear objective in introduction with appropriate detail on experimental methods and apparatus	5		What is the objective of the TCLab and the results? What should the audience to do, think, or feel differently because of this document? What are the OP, PV, SP? No need to include a photo of the device but do describe it your own words with a couple sentences. Discuss the significance ("why") not just the procedure ("what") for the methods.
Appropriate figure(s), graph(s), tables(s) to adequately support results and conclusions	10		Include figure (under) and table above) headings. Label trends and include x-labels and y-labels. Figures should not have a title. Annotate figures to highlight specific information that is important to support the conclusions. Tables do not report raw data but are synthesized summaries of results or comparisons.
Results and Discussion with appropriate analysis, accurate results, clear logic, and persuasive arguments	15		Derive 1st principles model and show how it compares with empirical model. Answer questions such as (1) is radiative heat transfer significant? (2) is heater to temperature response a first order or second order response? (3) what disturbances affect the system? (4) what 1st principles parameters are uncertain and can be adjusted to match data? (5) what controller tuning parameters are best? (6) what controller performance criteria are used to judge best performance?
Clear conclusions and recommendations supported by the data	10		Summarize main results with an emphasis on recommended actions as a result of this study. What are the limitations of the results and recommended future work or extensions that should be considered?
Model Performance	25		Model Integral Absolute Error with Test Script Provide K_p, τ_p, θ_p, K_d Model IAE = $\sum\|T_{meas,1} - T_{pred,1}\| + \sum\|T_{meas,2} - T_{pred,2}\|$
Control Performance	25		Control Integral Absolute Error with Test Script Provide K_c, τ_I, τ_D, K_{ff} Control IAE = $\sum\|T_{SP,1} - T_{meas,1}\| + \sum\|T_{SP,2} - T_{meas,2}\|$