Grading Rubric:

CIVIL-309, Project I, Part I (*Geospatial Analysis with CityTherm*) (29 Points)

1. Identifying Thermal Extremes (4 Points)

- (1 pt) Screenshot & LST data table.
  Screenshot is clear, shows 6 valid spots (3 hot, 3 cool), and all 6 LST values are correctly entered in the table. All spots have >10% building fraction
- (1 pt) Rural reference description.
  The description of the rural reference LST is clear, logical, and based on valid criteria (e.g., low building density, high pervious cover, LCZ D/A, etc.)
- (1 pt) Surface UHI calculations and observation (all 6).
  All 6 Surface UHI values are calculated correctly + observations
- (1 pt) Canopy UHI calculations (all 6).
  All 6 Canopy UHI values are calculated correctly

2. Local Climate Zone (LCZ) Analysis (3 Points)

- (1 pt) LCZ data table.
  All 6 Cell IDs and their corresponding LCZ Classifications are correctly entered
- (2 pts) Alignment justification.
  The justification clearly and logically connects the visual observations from Q1 (e.g., "dense buildings," "open space") to the formal LCZ classifications. Correctly identifies any anomalies (like a cool LCZ 2) and attempts an explanation.

3. Quantitative Analysis of Urban Fabric (5 Points)

- (1 pt) Land Cover table.
  All 24 data points (6 spots x 4 variables) are filled in correctly.
- (1 pt) Urban Morphology table.
  All 24 data points (6 spots x 4 variables) are filled in correctly.
- (3 pts) Comparative analysis.
  The analysis is comprehensive. It correctly identifies the key differences between hot and cool spots based on the tables. Must mention both land cover (e.g., impervious/pervious fractions) and morphology (e.g., SVF, Aspect Ratio).

4. Solar Irradiation Analysis (4 Points)

- (1 pt) Irradiation data table.
  All 12 data points (6 spots x 2 seasons) are filled in correctly.
- (2 pts) Thermal implications (Summer/Winter).
  Provides a clear and correct answer for both seasons. Correctly identifies summer irradiation as a liability (solar heat gain, cooling demand). Correctly identifies winter irradiation as a benefit (passive heating, reduced heating demand).

- (1 pt) Connection to urban form.
  Correctly explains how morphology causes irradiation differences. Must connect variables like SVF, density, or height to the concept of mutual shading.

5. Hypothesis and Correlation (10 Points)

- 5a. Analysis of Parameters: 2 points
  Provides a physically sound potential effect for all 4 parameters: Height: Shading (cool) but also heat storage/blocked ventilation (warm). SVF: Low SVF traps longwave radiation (warm); High SVF allows cooling (cool). Aspect Ratio: High H/W (canyons) traps heat (warm). FAI: High FAI impedes airflow/ventilation (warm).
- 5b. Hypothesis Formulation: 1 point
  The hypothesis is clear, testable, and identifies a single variable with a predicted direction of effect (e.g., "Higher impervious fraction... causes higher LST").
- 5c. Plots (Scatter & Heatmap): 5 points (e.g., 2.5 pts per plot)
  (2.5 pts) Inserts a 2x2 grid of scatter plots. Plots must have LST on the y-axis, correct morph variables on the x-axis, a trendline, and R^2/equation.
  (2.5 pts) Inserts a Spearman Correlation Heatmap that correctly includes LST and all 8 specified land cover/morphology variables
- 5d. Interpretation & Validation: 2 points
  (Note: As instructed, please create new columns in the CIVIL-309_2025_Grading.xlsx file for these subgrades: Q5a, Q5b, Q5c, Q5d)
  Correctly interprets the 4 scatter plots and explicitly states whether they support or refute the hypothesis from 5b, with justification. Correctly identifies the variables with the highest positive and negative correlation from the heatmap and discusses the finding in relation to the hypothesis.

6. Thermal Diagnosis (3 Points)

- (2 pts) Proposing specific interventions.
  Proposes at least 2-3 specific, relevant interventions (e.g., green roofs, permeable pavement, cool materials/high albedo, urban forestry, water features).
- (1 pt) Linking interventions to physical phenomena.
  Correctly and explicitly links each intervention to the physical phenomenon it influences (e.g., "increase evapotranspiration," "reduce solar radiation absorption," "increase albedo," "enhance convective cooling/street ventilation").

7. Urban Boundary Layer Structure (1.5 Points)

- *(0.5 pts) Correctly identifies (a) as the daytime convective/mixed boundary layer and identifies (b) as the nighttime stable boundary layer (with an urban plume).*
- *(1 pt) Provides a clear physical explanation for the difference (e.g., Ground temperature is greater than air temperature for all locations during the daytime, whereas at night it is lower in rural areas; daytime is thicker due to greater heat emission).*

8. Energy Flows in the Urban Environment (5 Points)

(2.5 pts) Daytime heat fluxes are shown in full; (2 pt) Nighttime heat fluxes are shown in full; (0.5 pt) Elaborated drawings with fine details

Shown comprehensively and correctly should include: (i) Proper indication of heat flux directions (e.g., shortwave radiation from the Sun, longwave/thermal radiation from surfaces, anthropogenic heat QF from human-related sources, etc.); (ii) clear representation of heat storage and its direction (absorption during the day, release at night); (iii) inclusion of radiation reflections, etc. Arrows are properly located (e.g., conduction should be within the solid, convection in the air).

9. Properties of Urban Materials (1.5 Points)

(0.75 pts) (a) Metal: Correctly explains the temperature profile (heats/cools fast) using its physical properties (e.g., low heat capacity and high thermal conductivity or high thermal diffusivity). (0.75 pts) (b) Brick: Correctly explains the profile (heats/cools slowly) using its properties (e.g., high heat capacity / Storage / thermal mass/ low thermal diffusivity), which results in heat storage and delayed release.

10. Convection Analysis (4 Points)

(1 pt) Correctly calculates the Reynolds number (Re) (approx. 505,000) and Prandtl number (Pr) (approx. 0.70-0.71).
(1 pt) Correctly identifies the flow as turbulent and calculates the Nusselt number (Nu) (approx. 1200-1202) and the convective heat transfer coefficient (h) (approx. 17.0 W/m^2K).
(1 pt) Correctly calculates the final convective heat transfer rate (approx. 595 W/m^2).
(1 pt) Correctly compares the magnitude with incident solar radiation, noting it is about 81.5% or solar radiation is only 1.22 times greater than the convective flux.

11. Radiation Analysis (4 Points)

(1 pt) Correctly calculates the Net Shortwave Radiation (K^*).
$K*=(1-\alpha)\times K\downarrow=(1-0.90)\times 750=75 W/m2$.
(2 pt) Correctly calculates the Net Longwave Radiation (L^*).
Incoming: $L\downarrow=\epsilon_{env}\sigma T_{env}^4\approx 454.9 W/m2$.
Outgoing: $L\uparrow=(\epsilon_s\sigma T_s^4)+((1-\epsilon_s)L\downarrow)\approx 505.3 W/m2$
Net Longwave: $L^*=L\downarrow-L\uparrow\approx -50.4 W/m2$
(1 pt): Correctly find the final Total Radiation Budget ($Q*$).
$Q*=K*+L*=75+(-50.4)=24.6 W/m2$.

12. Evaporation Analysis (5 Points)

(1 pt) Actual Evaporation Rate (Eact). $Eact=QE/Lv\approx 4.3\times 10{-}5 kg/(m2\cdot s)$.
(1 pt) Radiative Component (ES) of potential evaporation. Requires: $QG=150W/m2$.
$ES=[\Delta/(\Delta+\gamma)]\times(Q*-QG)/Lv\approx 11.58\times 10{-}5 kg/(m2\cdot s)$.
(1 pt) Aerodynamic Component (ET) of potential evaporation. Requires: $Ea\approx 1.43\times 10{-}5 kg/(m2\cdot s)$.
$ET=[\gamma/(\Delta+\gamma)]\times Ea\approx 0.32\times 10{-}5 kg/(m2\cdot s)$.

(1 pt) sums the components to find the final Total Potential Evaporation Rate (Epot)
$E_{pot} = E_S + E_T \approx 11.9 \times 10^{-5} kg/(m^2 \cdot s)$.
(1 pt) compares the components and states that the radiative term is dominant.
e.g. "The radiation term E_S is much greater" or "The aerodynamic term E_T is much smaller ".