UNIVERSITY MECHANICAL ENGINEERING • EXERCISE SHEET

10.4 Radiation

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS emissivity

Objective

Find radiation exchange from a surface to its surroundings and between two parallel plates, linearise it as a coefficient h_r, and size a radiation shield.

1 Key knowledge and worked examples

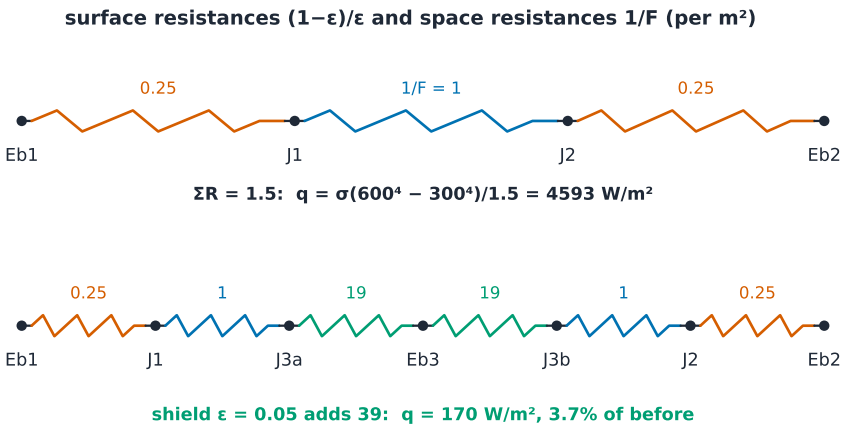
■ Surface and space resistances

- Small body in a large room: $q = \varepsilon\sigma A(T_s^4 - T_{sur}^4)$, temperatures in kelvin, **emissivity** ε, $\sigma = 5.67 \times 10^{-8}$ W/(m^2 · K^4).
- Linearised: $h_r = \varepsilon\sigma(T_s^2 + T_{sur}^2)(T_s + T_{sur})$, in parallel with h_c.
- Large parallel plates per m^2: $q = \sigma(T_1^4 - T_2^4)/(1/\varepsilon_1 + 1/\varepsilon_2 - 1)$.
- A shield adds $1/\varepsilon_{s1} + 1/\varepsilon_{s2} - 1$ to the denominator.

■ Worked example. A radiation shield

Oven wall 600 K, casing 300 K, both $\varepsilon = 0.8$; per m^2.

- $q = \sigma(600^4 - 300^4)/(1/0.8 + 1/0.8 - 1) = \mathbf{4593}$ W/m^2.
- A polished shield ($\varepsilon = 0.05$) adds $2/0.05 - 1 = 39$: $q = \mathbf{170}$ W/m^2, 3.7% of before.



2 Practice

$\sigma = 5.67 \times 10^{-8}$ W/(m^2 · K^4); add 273.15 for kelvin.

2.1 A surface at 80 °C ($\varepsilon = 0.9$) sits in a large room at 20 °C. Find the radiated flux (one decimal, W/m^2). [3]

2.2 Find h_r for that surface (two decimals, W/(m^2 · K)) and say how it compares with a still-air h_c of about 10. [3]

3 Exam-style questions

3.1 Two large parallel plates at 500 K and 300 K both have $\varepsilon = 0.7$. (a) Find the exchange per m^2 (one decimal). (b) A thin shield with $\varepsilon = 0.1$ on both sides is placed between them: find the new exchange (one decimal) and its fraction of (a) (one decimal, %). (c) Find the shield temperature (nearest K). [8]