

Convection - External Flow Example Values

Flat Plate

Fluid Properties of Air at Average Temperature of 300 K

| Textbook Values | EES Values |
|---|---|
| <ul style="list-style-type: none">• $c_p = 1007$ [J/kg-K]• $\mu = 184.6E-7$ [N-s/m²]• $k = 26.3E-3$ [W/m-K]• $\rho = 1.1614$ [kg/m³] | <ul style="list-style-type: none">• $c_p = 1005$ [J/kg-K]• $\mu = 185.7E-7$ [N-s/m²]• $k = 25.65E-3$ [W/m-K]• $\rho = 1.177$ [kg/m³] |

Case 1:

- Free-stream velocity: 15 m/s
- Length of plate: 1.5 m

Calculated Values

- $L_{critical} = 0.53$ m → use mixed flow correlation
- Reynolds number at end of plate: 1.42 E6
- $h_{bar} = 34.28$ W/m²K

Case 2:

- Free-stream velocity: 5 m/s
- Length of plate: 0.25 m

Calculated Values

- $L_{critical} = 1.579$ m → use laminar flow values
- Reynolds number at end of plate: 79,186
- $h_{bar} = 17.24$ W/m²K

Case 3:

- Free-stream velocity: 5.5 m/s
- Length of plate: 1.5 m

Calculated Values

- $L_{critical} = 1.45$ m → Should check both values – too close to tell from equations alone
- Reynolds number at end of plate: 522,629
- $h_{bar_laminar} = 7.383$ W/m²K
- $h_{bar_mixed} = 7.965$ W/m²K

Cylinder in Cross-Flow

Average temperature of 300 K (from textbook)

- $c_p = 1007$ [J/kg-K]
- $\mu = 184.6E-7$ [N-s/m²]
- $k = 26.3E-3$ [W/m-K]
- $\rho = 1.1614$ [kg/m³]

Case 1:

- Free-stream velocity: 10 m/s
- Diameter of cylinder: 0.0127 m

Calculated Values

- $Re_D = 7,990 \rightarrow$ Look up values for C and n
- $C = 0.193$
- $n = 0.618$
- $h_{bar} = 91.9$ W/m²K

Case 2:

- Free-stream velocity: 10 m/s
- Diameter of cylinder: 0.1 m

Calculated Values

- $Re_D = 62,914 \rightarrow$ Look up values for C and n
- $C = 0.0266$
- $n = 0.805$
- $h_{bar} = 45.46$ W/m²K

Case 3:

- Free-stream velocity: 5 m/s
- Diameter of cylinder: 0.00008 m (approximate human hair diameter)

Calculated Values

- $Re_D = 25.17 \rightarrow$ Look up values for C and n
- $C = 0.911$
- $n = 0.385$
- $h_{bar} = 923.7$ W/m²K