HW 1.2

**By**

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MET 440 - Heat Transfer

Dr. Ayala

CH4 Problems

Question 4-3

**4-3.** Consider a furnace wall [$k = 1\ \text{W}/(\text{m} \cdot °\text{C})$] with the inside surface at 1000°C and the outside surface at 400°C. If the heat flow through the wall should not exceed 2000 $\text{W}/\text{m}^2$, what is the minimum wall thickness $L$?

**Solution**

k = ~~heat T coefficient~~ thermal conductivity

h = heat T coefficient

heat flow, heat flux $q = W/m^2$

3.

$$q = k\,\frac{T_1 - T_2}{L} \quad W/m^2$$

$$L = \frac{k(T_1 - T_2)}{q} = 1\ \frac{W}{m\,°C}\ \Big|\ (1000 - 400)\ °C\ \Big|\ \frac{m^2}{2000\ W}$$

.3 m

Question 4-10

**4-10.** A brass condenser tube [$k = 115\ \text{W}/(\text{m} \cdot °\text{C})$] with an outside diameter of 2 cm and a thickness of 0.2 cm is used to condense steam on its outer surface at 50°C with a heat transfer coefficient of 2000 $\text{W}/(\text{m}^2 \cdot °\text{C})$. Cooling water at 20°C with a heat transfer coefficient of 5000 $\text{W}/(\text{m}^2 \cdot °\text{C})$ flows inside.

*(a)* Determine the heat flow rate from the steam to the cooling water per meter of length of the tube.

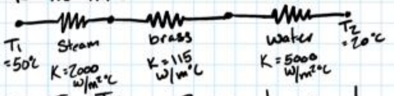
*(b)* What would be the heat transfer rate per meter of length of the tube if the outer and the inner surfaces of the tube were at 50°C and 20°C, respectively? Compare this result with *(a)*, and explain the reason for the difference between the two results.

**Solution**

4-10 brass Condensor tube ($K = 115\ W/m°C$) w/ outside Diameter of 2cm & thickness of 0.2 cm. $T_{out} = 50°C$ w/ heat transfer Coefficent of ($2000\ W/m^2 \cdot °C$) $T_{in} = 20°C$ w/ hT Coefficient of ($5000\ W/m^2 \cdot °C$)

a) Determine the heat flow rate from steam to the Cooling water per meter lenth of tube


b = 2cm (0.02 m)
a = 1.8cm (0.018m)
K = 115 W/m°C




$$Q = \frac{T_1 - T_2}{R_{eq}} \qquad R_{eq} = \frac{1}{h_s \cdot A} + \frac{1}{\frac{2\pi L}{\ln(b/a)} K} + \frac{1}{h_w \cdot A}$$

$$R_{eq} = \frac{1}{2000\ W/m^2°C \cdot 1m^2} + \frac{1}{\frac{2\pi \cdot 1m}{\ln\left(\frac{0.02}{0.018}\right)} \cdot 115\ W/m°C} + \frac{1}{5000\ W/m^2°C \cdot 1m^2}$$

$$R_{eq} = \frac{1}{2000} + \frac{1}{6858.04} + \frac{1}{5000} = R_{eq} = 8.458E\text{-}4$$

$$Q = \frac{T_1 - T_2}{R_{eq}} = \frac{50 - 20}{8.458E\text{-}4} = 35468.78\ W/m°C$$

b) what is the heat transfer if outer & inner surfaces were 50°C & 20°C

Equation

$$Q = \left(\frac{2\pi L}{\ln(b/a)}\right) K \Delta T$$

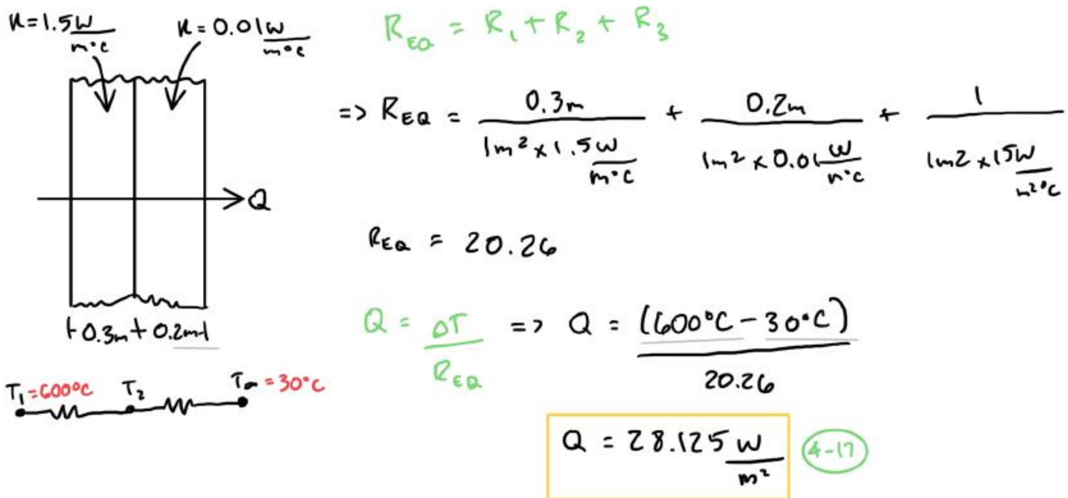
$$Q = \frac{2\pi(1m)}{\ln(0.02/0.018)} \cdot 115\ W/m°C \cdot (50°C - 20°C)$$

$$Q = 205741.11\ W/m°C$$

Question 4-17

**4-17.** An industrial furnace is made of fireclay brick 0.3 m thick with a thermal conductivity of 1.5 W/(m · °C). The outside surface is to be insulated with a material that has a thermal conductivity of 0.01 W/(m · °C) and a thickness of 0.2 m. The inner surface of the furnace is kept at 600°C, while the outer surface of the insulation material is exposed to cool air at 30°C with a heat transfer coefficient of 15 W/($m^2$ · °C). Calculate the heat flow rate across the layers per square meter of surface area and the outer surface temperature of the furnace.

## Solution




Question 4-23

**4-23.** Determine the interface temperature $T_1$ and the surface temperature $T_3$ of the composite wall shown in Fig. P4-23.

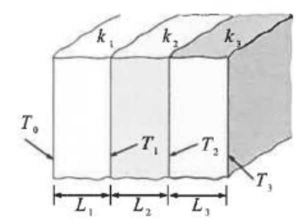
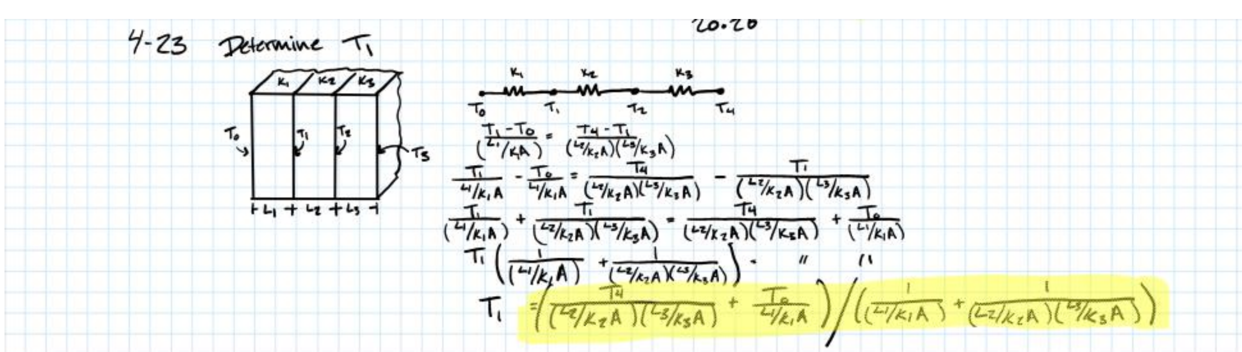



Figure P4-23

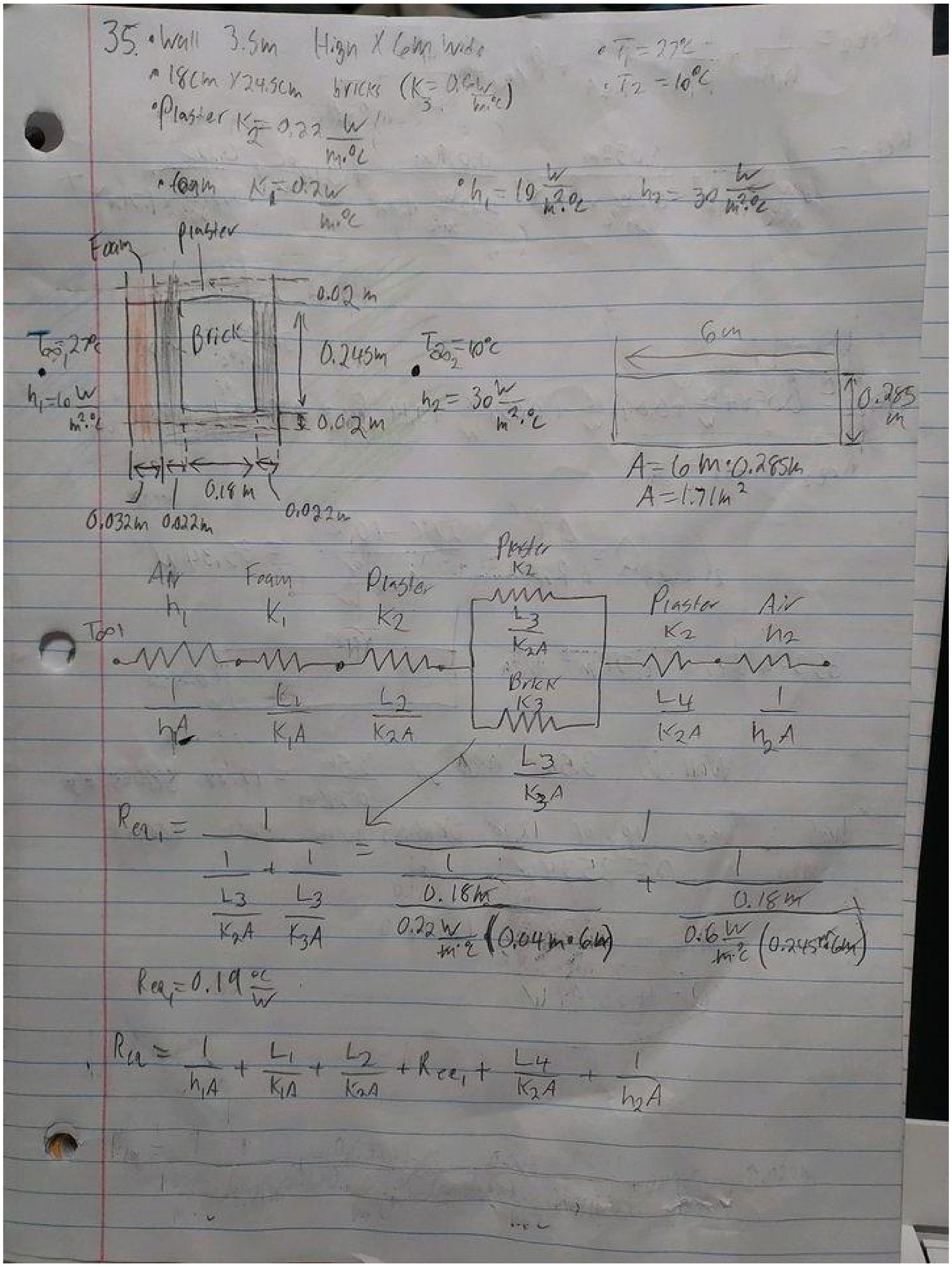
**Solution**




Question 4-35

**4-35.** A 3.5-m-high and 6-m-wide wall consists of long 18-cm × 24.5-cm cross section horizontal bricks ($k = 0.6\ \mathrm{W/(m \cdot °C)}$) separated by 4-cm-thick plaster layers ($k = 0.22\ \mathrm{W/(m \cdot °C)}$). There are also 2.2-cm-thick plaster layers on each side of the brick and a 3.2-cm-thick rigid foam ($k = 0.2\ \mathrm{W/(m \cdot °C)}$) on the inner side of the wall, as shown in Figure P4-35. The indoor and outdoor temperatures are

## Solution



$$R_{eq_2} = \frac{1}{h_1 A} + \frac{L_1}{K_1 A} + \frac{L_2}{K_2 A} + R_{eq_1} + \frac{L_4}{K_2 A} + \frac{1}{h_2 A}$$

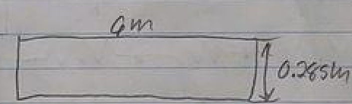
$$R_{eq_2} = \frac{1}{10\frac{W}{m^2\cdot°C}\cdot 1.71m^2} + \frac{0.032m}{0.2\frac{W}{m\cdot°C}\cdot 1.71m^2} + \frac{0.022m}{0.22\frac{W}{m\cdot°C}\cdot 1.71m^2} + 0.19\frac{°C}{W} + \frac{0.22m}{0.22\frac{W}{m\cdot°C}\cdot 1.71m^2} + \frac{1}{30\frac{W}{m^2\cdot°C}\cdot 1.71m^2}$$

$$R_{eq_2} = 0.0584\frac{°C}{W} + 0.094\frac{°C}{W} + 0.058\frac{°C}{W} + 0.19\frac{°C}{W} + 0.058\frac{°C}{W} + 0.019\frac{°C}{W}$$

$$R_{eq_2} = 0.481\frac{°C}{W}$$

$$Q = \frac{\Delta T}{R_{eq2}} = \frac{27°C - 10°C}{0.481\frac{°C}{W}} = 35.34W$$

35.34W per 1.71 m² Area




Wall is 3.5m high so $\frac{3.5m}{0.285m} = 12.28$ Sections high

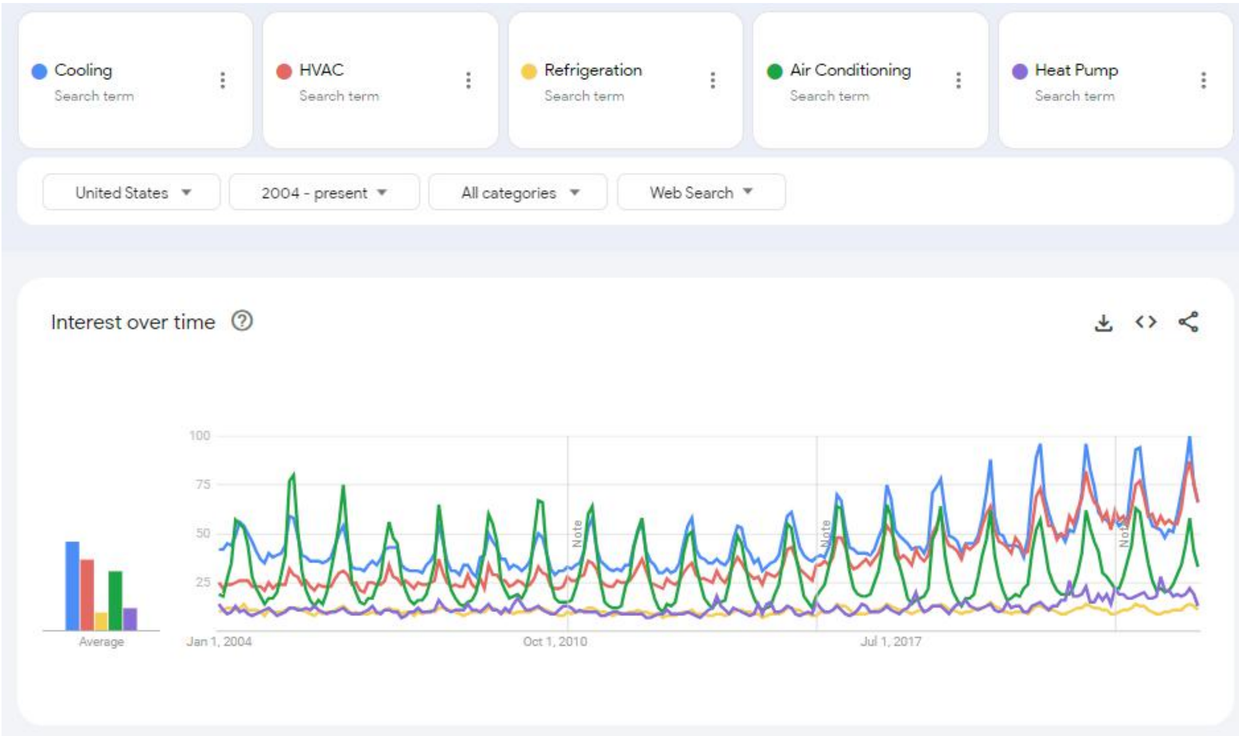
Wall is made up of 12.28 Sections with each Section with a $Q = 35.34W$

$$Q_{total} = 35.34W \cdot 12.28$$

$$Q = 433.99W$$

Trend Report

From Google Trends




As reported from Google Trends, the terms Cooling and HVAC were recorded to be in Google's search engine at an increasing rate in the US. The less popular terms in regards to what we anticipated to be on the lower side of the trendline data were still searched consistently, even growing, in the search engine. Additionally, the data peaks for most of the cooling terms around summer time which is typically when it gets uncomfortable in hot rooms. This data concludes that cooling systems are becoming more desired and relevant and also that people may be searching cooling and HVAC terms to fix their air conditioning or to invest in an AC unit.

From Google Finance


Upon research, John Bean Technologies (JBT), was a major corporation that focuses on making refrigeration systems that preserve food and beverages.They offer cooling systems that ensure maximum cooling and efficiency. Their products are called Cooling & Applied Technologies (C.A.T.) and they feature chilling systems, injection systems, whole muscle pumps, and plant monitoring and weighing systems. According to this data, stocks for JBT are highly valued and are performing significantly better than the previous day at the stock market. Companies like JBT are able to continue researching and developing new products because it keeps and acquires new customers that need refrigeration.


Another company, Aaon Inc, is steadily succeeding during the last 5 years according to this data with a 141% growth. This company specializes in making HVAC systems. These companies are both examples that investors are getting on board with cooling systems staying relevant.