HW 1.1

By

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MET 440 - Heat Transfer

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CH1 Problems

Question 1-7

1-7. The heat flow through a 4-cm-thick insulation layer for a temperature difference of 200°C across the surfaces is 500 W/m^2. What is the thermal conductivity of the insulating material?

Solution

$\Delta x = 4cm \Rightarrow \Delta x = 0.04m, \quad \Delta T = 200\,^\circ C, \quad q = 500 \frac{W}{m^2}$

$$q = k \frac{\Delta T}{\Delta x} \Rightarrow k = \frac{q\,\Delta x}{\Delta T}$$

$$k = \frac{\left(500 \frac{W}{m^2}\right)(0.04m)}{200\,^\circ C}$$

$$\boxed{k = 0.1 \frac{W}{m\,^\circ C}}$$

Question 1-16

1-16. Cold air at 10°C flows over a 2-cm-OD tube, as illustrated in Fig. P1-13. The outside surface of the tube is maintained at 110°C. If the heat transfer coefficient between the outside surface of the tube and the air is 100 W/(m^2 · °C), determine the rate of heat flow to the air over the 5-m length of the tube.

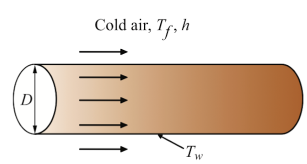


Figure P1-16

Solution

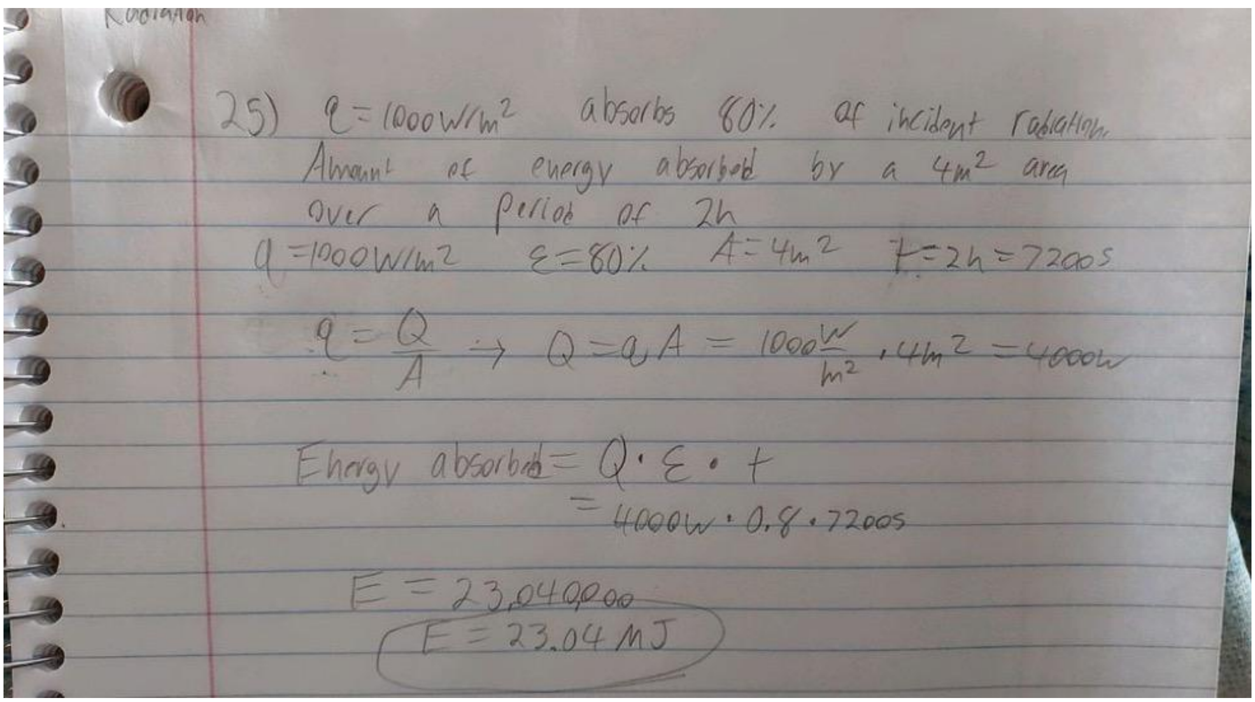
16. $q = h(T_H - T_C) = 100 \frac{W}{m^2\,°C} \cdot (110 - 10)\,°C = 10000 \frac{W}{m^2}$

$Q = qA = 10000 \frac{W}{m^2} \cdot (.02\,m)(5\,m)\,\pi = \boxed{3141.59\,W}$

Question 1-25

1-25. A radiation flux of 1000 W/m^2 is incident upon a surface that absorbs 80 percent of the incident radiation. Calculate the amount of radiation energy absorbed by a 4-m^2 area of the surface over a period of 2 h.

Solution



Radiation

25) $q = 1000\,W/m^2$ absorbs 80% of incident radiation

Amount of energy absorbed by a $4m^2$ area over a period of 2h

$q = 1000\,W/m^2$ $\varepsilon = 80\%$ $A = 4m^2$ $t = 2h = 7200s$

$q = \frac{Q}{A} \rightarrow Q = qA = 1000\frac{W}{m^2} \cdot 4m^2 = 4000W$

Energy absorbed $= Q \cdot \varepsilon \cdot t$

$= 4000W \cdot 0.8 \cdot 7200s$

$E = 23{,}040{,}000$

$E = 23.04\,MJ$

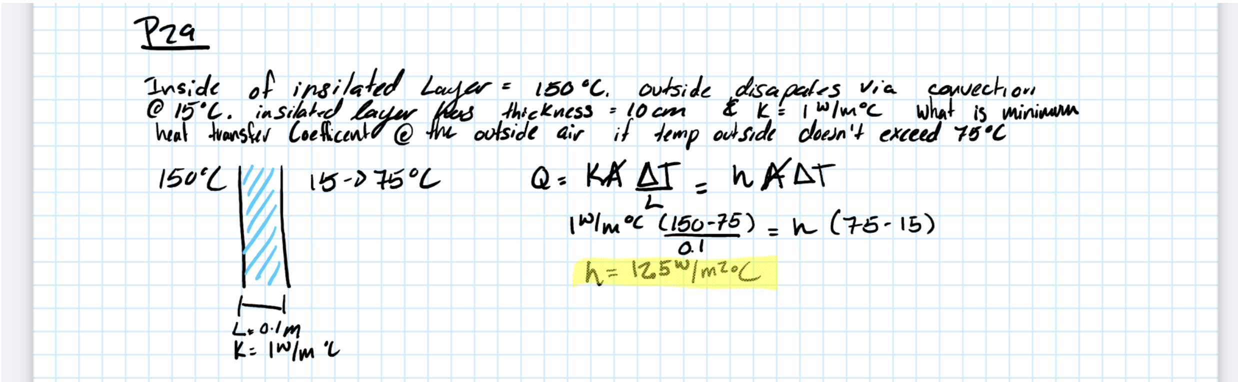
Question 1-29

1-29. The inside surface of an insulation layer is maintained at 150°C and the outside surface dissipates heat by convection into air at 15°C. The insulation layer has a thickness of 10 cm and a thermal conductivity of 1 W/(m · °C). What is the minimum value of the heat transfer coefficient at the outside surface, it the temperature at the outside surface should not exceed 75°C?

Calculate the increase in its emissive power.

Answer: $12.5 \frac{W}{m^{2}°C}$.

Solution



Project first impressions

First impressions: Our design would consist of a type of apparatus that pumps relatively cold water through a chamber containing the 12 cans of soda. Using a centrifugal pump and an appropriate cooling medium, heat will be rapidly removed from the cans via forced convection. Our cooling medium is as yet undetermined. Pump capacity, chamber capacity, and flow rate all are undetermined at this point.

Some things to consider: overall shape and layout of the design, position of cans relative to water flow, pump capacity and power source, cooling medium, flow rate, and all necessary calculations to ensure the system works as prescribed.