In-Class Exercises n°03

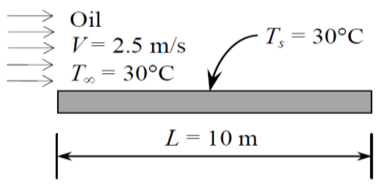
Exercise 3.1

Consider laminar flow over a flat plate. Will the friction coefficient change with distance from the leading edge? How about the heat transfer coefficient?

How are the average frictions and heat transfer coefficients determined in flow over a flat plate?

Exercise 3.2

Engine oil at **80°C** flows over a **10-m-long** flat plate whose temperature is **30°C** with a velocity of **2.5 m/s**. Determine the **total drag force** (**F_D**) and **the rate of heat transfer** (**q_v**) over the entire plate per unit width.

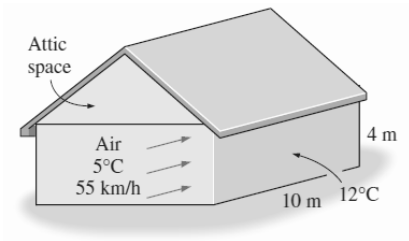


(Figure 3.1)

Exercise 3.3

During a cold winter day, wind at **55 km/h** is blowing parallel to a **4-m-high** and **10-m-long** wall of a house. If the air outside is at **5°C** and the surface temperature of the wall is **12°C**.

- Determine the rate of heat loss from that wall by convection.
- What would your answer be if the wind velocity was doubled?



(Figure 3.2)

Exercise 3.4

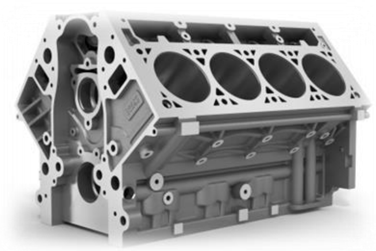
Air at **60°F** flows over a **10-ft-long** flat plate at **7 ft/s**. Determine the local friction (**$C_{f,x}$**) and heat transfer coefficients (**h_x**) at intervals of **1 ft**, and plot the results against the distance from the leading edge.

Exercise 3.5

Mercury at **25°C** flows over a **3-m-long** and **2-m-wide** flat plate maintained at **75°C** with a velocity of **0.8 m/s**. Determine the rate of heat transfer (**q_v**) from the entire plate.

Exercise 3.6

Consider a hot automotive engine, which can be approximated as a **0.5-m-high**, **0.40-m-wide**, and **0.8-m-long** rectangular block. The bottom surface of the block is at a temperature of **100°C** and has an emissivity of **0.95**. The ambient air is at **20°C**, and the road surface is at **25°C**. Determine the rate of heat transfer (**q**) from the bottom surface of the engine block by convection (**q_v**) and radiation (**q_r**) as the car travels at a velocity of **80 km/h**. assume the flow to be turbulent over the entire surface because of the constant agitation of the engine block.

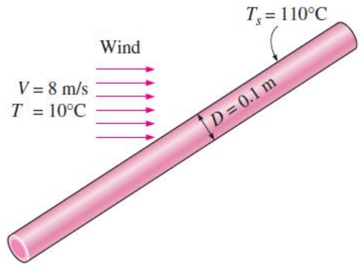


(Figure 3.3)

Exercise 3.7

A long **10-cm-diameter** steam pipe whose external surface temperature is **110°C** passes through some open area that is not protected against the winds (**Fig. 3.4**).

Determine the rate of heat loss from the pipe per unit of its length when the air is at **1 atm** pressure and **10°C** and the wind is blowing across the pipe at a velocity of **8 m/s**.

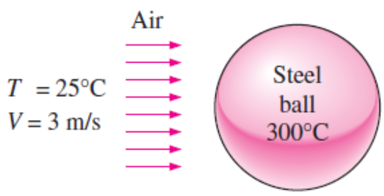


(Figure 3.4)

Exercise 3.8

A **25-cm-diameter** stainless steel ball (**ρ = 8055 kg/m^3**, **C_p = 480 J/kg.°C**) is removed from the oven at a uniform temperature of **300°C** (**Fig. 3.5**). The ball is then subjected to the flow of air at **1 atm** pressure and **25°C** with a velocity of **3 m/s**. The surface temperature of the ball eventually drops to **200°C**.

Determine the average convection heat transfer coefficient during this cooling process and estimate how long the process will take.

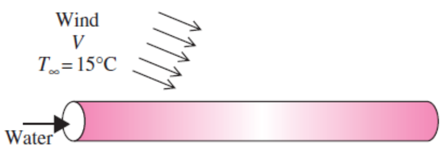


(Figure 3.5)

Exercise 3.9

In a geothermal power plant, the used geothermal water at **80°C** enters a **15-cm-diameter** and **400-m-long** uninsulated pipe at a rate of **8.5 kg/s** and leaves at **70°C** before being reinjected back to the ground. Windy air at **15°C** flows normal to the pipe.

Disregarding radiation, determine the average wind velocity in **km/h**.

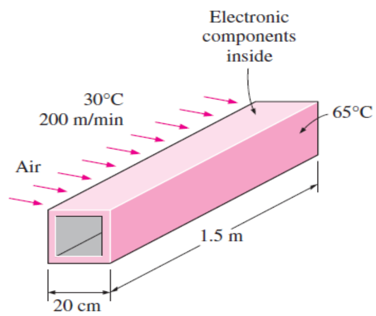


(Figure 3.6)

Exercise 3.10

The components of an electronic system are located in a **1.5-m-long** horizontal duct whose cross section is **20 cm x 20 cm**. The components in the duct are not allowed to come into direct contact with cooling air, and thus are cooled by air at **30°C** flowing over the duct with a velocity of **200 m/min**.

If the surface temperature of the duct is not to exceed **65°C**, determine the total power rating of the electronic devices that can be mounted into the duct.



(Figure 3.7)