Introduction to Thermodynamics and Heat Transfer (ECE 309)
Suggested Problems for Chapter 4

1. Water flows through a shower head steadily at a rate of 10 L/min (Fig. 1). An electric resistance heater placed in the water pipe heats the water from 16 °C to 43 °C. Taking the density of water to be 1 kg/L, determine the electric power input to the heater, in kW.

In an effort to conserve energy, it is proposed to pass the drained warm water at a temperature of 39°C through a heat exchanger to preheat the incoming cold water. If the heat exchanger has an effectiveness of 0.50 (that is, it recovers only half of the energy which can possibly be transferred from the drained water to incoming cold water), determine the electric power input required in this case. If the price of the electric energy is 8.5 cents/kWh, determine how much money is saved during a 10 min shower as a result of installing this heat exchanger.

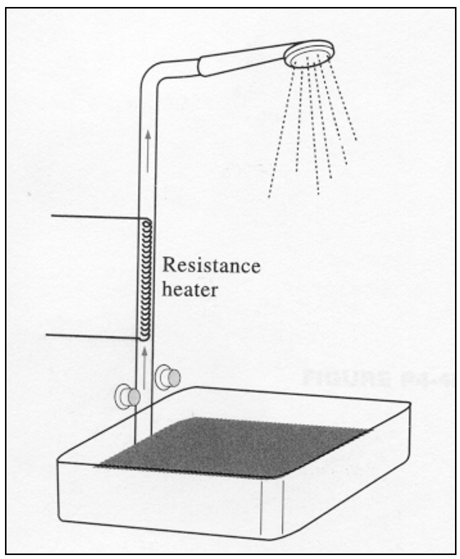

Fig. 1

2. A building with an internal volume of 400 m^3 is to be heated by a 30-kW electric resistance heater placed in the duct inside the building (Fig. 2). Initially, the air in the building is at 14 °C, and the local atmospheric pressure is 95 kPa. The building is losing heat to the surroundings at a steady rate of 450 kJ/min. Air is forced to flow through the duct and the heater steadily by a 250-W fan, and it experiences a temperature rise of 5 °C each time it passes through the duct, which may be assumed to be adiabatic.

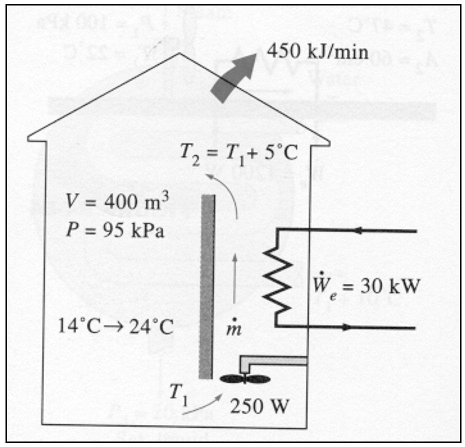

Fig. 2

(a) How long will it take for the air inside the building to reach an average temperature of 24 °C?

(b) Determine the average mass flow rate of air through the duct.

Answers: (a) 146 s, (b) 6.02 kg/s

3. The ventilating fan of the bathroom of a building has a volume flow rate of 30 L/s, and runs continuously (Fig. 3). The building is located in San Francisco, California where the average winter temperature is 12.2 °C, and is maintained at 22 °C at all times. The building is heated by electricity whose unit cost is $0.091/kWh. Determine the amount and cost of the heat "vented out" per month in winter.

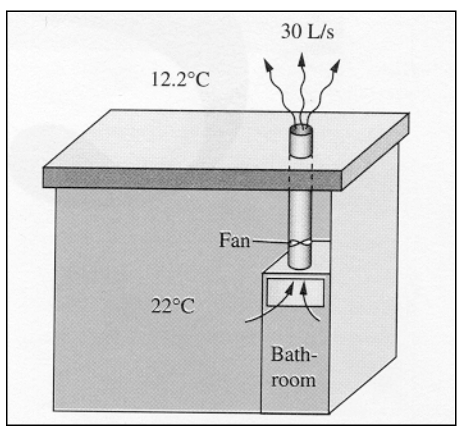

Fig. 3