

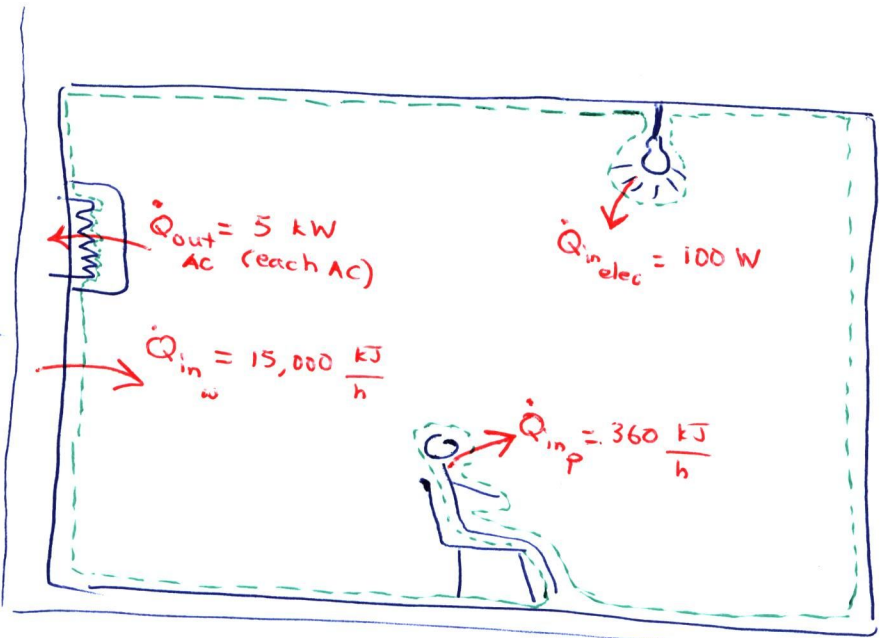
2–44 A classroom that normally contains 40 people is to be air-conditioned with window air-conditioning units of 5-kW cooling capacity. A person at rest may be assumed to dissipate heat at a rate of about 360 kJ/h. There are 10 lightbulbs in the room, each with a rating of 100 W. The rate of heat transfer to the classroom through the walls and the windows is estimated to be 15,000 kJ/h. If the room air is to be maintained at a constant temperature of 21°C, determine the number of window air-conditioning units required. *Answer: 2 units*

Problem 2-44 8th Edition

- Number of people: 40
- Number of lightbulbs: 10
- We need to maintain the room at 21°C

Determine

Number of air-conditioners (N)



Solution:

The best choice of the system is only the air inside the room.

Energy interactions are:

* $\dot{Q}_{in,p} = 360 \frac{kJ}{h} = \frac{360}{3600} \frac{kJ}{s} = 0.1 \text{ kW} \rightarrow \dot{Q}_{in,p, total} = 0.1 \times 40 = 4 \text{ kW}$ (Number of people)

* $\dot{Q}_{in,elec} = W_{in,elec} = 10 \times 100 = 1000 \text{ W} = 1 \text{ kW}$ (Number of lightbulbs)

* $\dot{Q}_{in,w} = 15,000 \frac{kJ}{h} = \frac{15,000}{3,600} = 4.167 \text{ kW}$

* $\dot{Q}_{out} = N \times \dot{Q}_{out,AC} = N \times 5$ (Number of air conditioners)

Now apply the 1st law:

$$(\dot{Q}_{in} + \dot{W}_{in} + \dot{E}_{mass,in}) - (\dot{Q}_{out} + \dot{W}_{out} + \dot{E}_{mass,out}) = \underbrace{\Delta U + \Delta KE + \Delta PE}_{\Delta \dot{E}_{system}}$$

(No work input) (closed system) (No work output) (closed system) (stationary system)

$\rightarrow \dot{Q}_{in} - \dot{Q}_{out} = \Delta U$

Since we need to keep the temperature constant, the internal energy will not change $\rightarrow \Delta U = 0$ [$U_{initial} = U_{final}$]

$\rightarrow \dot{Q}_{in} - \dot{Q}_{out} = 0$. Change to the rate form; $\dot{Q}_{in} = \dot{Q}_{out}$

$\rightarrow [\dot{Q}_{in,p, total} + \dot{Q}_{in,elec} + \dot{Q}_{in,w}] = N \times \dot{Q}_{out,AC}$

$\rightarrow 4 + 1 + 4.167 = N \times 5 \rightarrow N = 1.83$

Since we need a whole (integer) number of air-conditioners;

$N = 1.83 \rightarrow 2$ (by rounding up)