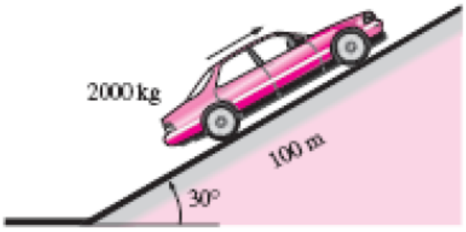
TD 1(Solutionnaire)

2.34



Analysis The total power required for each case is the sum of the rates of changes in potential and kinetic energies. That is,

$$\dot{W}_{\text{total}} = \dot{W}_a + \dot{W}_g$$

(*a*) $\dot{W}_a = 0$ since the velocity is constant. Also, the vertical rise is h = (100 m)(sin 30°) = 50 m. Thus,

$$\dot{W}_g = mg(z_2 - z_1)/\Delta t = (2000\text{ kg})(9.81\text{ m/s}^2)(50\text{ m})\left(\frac{1\text{ kJ}}{1000\text{ kg}\cdot\text{m}^2/\text{s}^2}\right)/(10\text{ s}) = 98.1\text{ kW}$$

and $\dot{W}_{\text{total}} = \dot{W}_a + \dot{W}_g = 0 + 98.1 = \mathbf{98.1\ kW}$

(*b*) The power needed to accelerate is

$$\dot{W}_a = \frac{1}{2}m(V_2^2 - V_1^2)/\Delta t = \frac{1}{2}(2000\text{ kg})\left[(30\text{ m/s})^2 - 0\right]\left(\frac{1\text{ kJ}}{1000\text{ kg}\cdot\text{m}^2/\text{s}^2}\right)/(10\text{ s}) = 90\text{ kW}$$

and $\dot{W}_{\text{total}} = \dot{W}_a + \dot{W}_g = 90 + 98.1 = \mathbf{188.1\ kW}$

(*c*) The power needed to decelerate is

$$\dot{W}_a = \frac{1}{2}m(V_2^2 - V_1^2)/\Delta t = \frac{1}{2}(2000\text{ kg})\left[(5\text{ m/s})^2 - (35\text{ m/s})^2\right]\left(\frac{1\text{ kJ}}{1000\text{ kg}\cdot\text{m}^2/\text{s}^2}\right)/(10\text{ s}) = -120\text{ kW}$$

and $\dot{W}_{\text{total}} = \dot{W}_a + \dot{W}_g = -120 + 98.1 = \mathbf{-21.9\ kW}$ (breaking power)

2.36

No. This is the case for adiabatic systems only.

2.37

Warmer. Because energy is added to the room air in the form of electrical work.

2.37

2-50 A classroom is to be air-conditioned using window air-conditioning units. The cooling load is due to people, lights, and heat transfer through the walls and the windows. The number of 5-kW window air conditioning units required is to be determined.

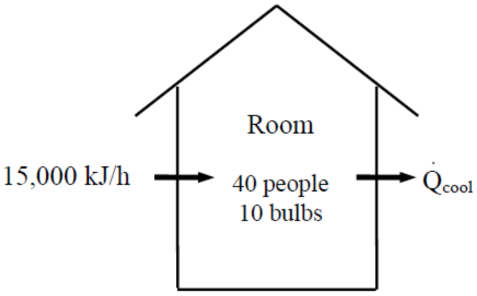
Assumptions There are no heat dissipating equipment (such as computers, TVs, or ranges) in the room.

Analysis The total cooling load of the room is determined from

$$\dot{Q}_{\text{cooling}} = \dot{Q}_{\text{lights}} + \dot{Q}_{\text{people}} + \dot{Q}_{\text{heat gain}}$$

where

$$\dot{Q}_{\text{lights}} = 10 \times 100 \text{ W} = 1 \text{ kW}$$
$$\dot{Q}_{\text{people}} = 40 \times 360 \text{ kJ / h} = 4 \text{ kW}$$
$$\dot{Q}_{\text{heat gain}} = 15{,}000 \text{ kJ / h} = 4.17 \text{ kW}$$



Substituting,

$$\dot{Q}_{\text{cooling}} = 1 + 4 + 4.17 = 9.17 \text{ kW}$$

Thus the number of air-conditioning units required is

$$\frac{9.17 \text{ kW}}{5 \text{ kW/unit}} = 1.83 \longrightarrow \mathbf{2 \text{ units}}$$

2.37 (version anglaise)

2-37 Water is heated in a pan on top of a range while being stirred. The energy of the water at the end of the process is to be determined.

Assumptions The pan is stationary and thus the changes in kinetic and potential energies are negligible.

Analysis We take the water in the pan as our system. This is a closed system since no mass enters or leaves. Applying the energy balance on this system gives

$$\underbrace{E_{\text{in}} - E_{\text{out}}}_{\substack{\text{Net energy transfer} \\ \text{by heat, work, and mass}}} = \underbrace{\Delta E_{\text{system}}}_{\substack{\text{Change in internal, kinetic,} \\ \text{potential, etc. energies}}}$$

$$Q_{\text{in}} + W_{\text{sh,in}} - Q_{\text{out}} = \Delta U = U_2 - U_1$$
$$30 \text{ kJ} + 0.5 \text{ kJ} - 5 \text{ kJ} = U_2 - 10 \text{ kJ}$$
$$U_2 = \mathbf{35.5 \text{ kJ}}$$

Therefore, the final internal energy of the system is 35.5 kJ.

2.19

2-19C It is a work interaction since the electrons are crossing the system boundary, thus doing electrical work.

2.20

It is a heat interaction since it is due to the temperature difference between the sun and the room.

2.21

2-21C This is neither a heat nor a work interaction since no energy is crossing the system boundary. This is simply the conversion of one form of internal energy (chemical energy) to another form (sensible energy).