A refrigerator works by absorbing heat from one region (the interior) and expelling it into another (typically behind it, where those dusty coils are). The trick is to expand a gas (called a "coolant") that is confined in a series of coils in contact with the cold interior so that it absorbs heat. That gas is then transferred to another series of coils that are in contact with the hot exterior where it is compressed so that it gives off heat.

Let's say you have an ideal refrigerator but a non-ideal roommate who regularly leaves the door ajar. Hence the distinction between "interior" and "exterior" is lost as air circulates freely between them. Note that air in the room is not the coolant, which is trapped in the coils. Can your refrigerator be good enough that it expels exactly the same amount of heat as it absorbs? Make your argument using the first law of thermodynamics. Tip: draw a PV diagram to understand the cycle.

Is the problem simply one of conservation of energy?

In this case it can. The first law of thermodynamics states that energy cannot be created nor destroyed, but only converted from one form to another. If the refrigerator takes in a certain amount of energy, x, then it MUST release x energy due to the first law of thermodynamics. Otherwise, energy has been destroyed.

Here, there is no distinction between warm and cold air!

The refrigerator will not be good enough to expel the same amount of heat as it absorbs, this is because the interaction between the warm air and the cool air of the environment and refrigerator. The fridge’s work increases as the constant distribution of warm air counteracts the cool air. The first Law states energy within close system is observed, the heat absorbed and expelled does not affect the total energy of the system. Because the refrigerator is electricity powered it would end up doing more work to maintain the equilibrium.

The first law of thermodynamics relates work done to heat transferred

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The first law of thermodynamics states that energy cannot be created or destroyed. The example of the refrigerator is a great example of heat energy being transferred. The refrigerator absorbs heat from the evaporator coil and the compressor does work to increase pressure and temperature. The coil then releases heat to the environment. When the door is left opened, warm air enters affecting the heat absorbed. The refrigerator will continue to expel heat, but not at the same rate.

If a thermodynamic process is “closed,” i.e. the system returns to its original state at the end of a cycle, which of the following must be zero for the cycle?

1. The system’s net work (i.e. “work done by” minus “work done on”)
2. The net heat added to the system (i.e. “heat added” minus “heat removed”)
3. The net change in internal energy of the system
4. all of these
5. none of these