ENGINEERING PHYSICS

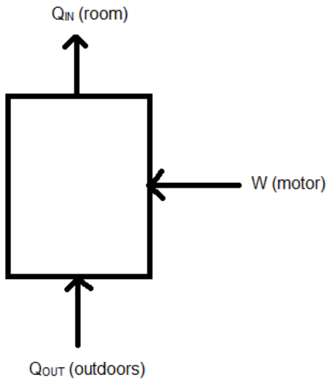
2-5 Heat Pumps

1. 120 W motor = W
600 W to the room from outdoors = Q_{IN}

(a) coefficient of performance $= \dfrac{\text{energy into 'hot' space}}{\text{work done for the transfer}}$

$= \dfrac{600\text{ W}}{120\text{ W}}$

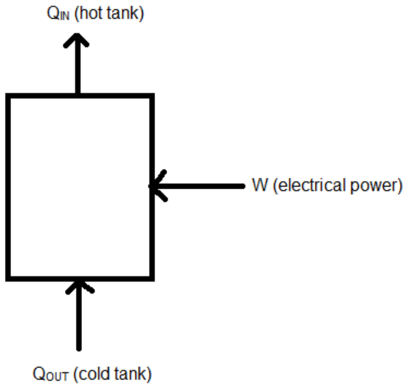
= 5



(b) Heat gained from outside:

W = 120 W
Q_{IN} = 600 W

$Q_{OUT} = Q_{IN} - W = 600 - 120 = 480$ W



2. Energy to hot water = Q_{IN} = 150 W
Electrical power supplied = W = 50 W

(a) $Q_{OUT} = Q_{IN} - W = 150 - 50 = 100$ W

(b) coefficient of performance $= \dfrac{150\text{ W}}{50\text{ W}} = 3$

3. A heat pump transfers energy from a cold space into a hot space in order to make the hot space warmer whereas a refrigerator is taking energy from warm objects to cool them down and thus heating the room (an effect that is not the focus of the operation).

The difference in what we want each to do is reflected in their definitions of their coefficient of performance.

Heat pump coefficient = $\dfrac{Q_{IN}}{W}$ Refrigerator coefficient = $\dfrac{Q_{OUT}}{W}$

Since $Q_{IN} = Q_{OUT} + W$ the numerator in the heat pump coefficient is greater than the numerator in the refrigerator coefficient so its value is greater.

4. Pump power = W = 5 W
Mass of water = 0.15 kg
Starting temperature = 15°C
Final temperature = 0°C
C_{WATER} = 4200 $Jkg^{-1}K^{-1}$
t = 940 s

(a) Heat energy extracted from the water = $mc\Delta T$

= 0.15 x 4200 x 15 (change in Kelvin is numerically identical)

= 9450 J

= 9.45 kJ or 9.45 x 10^3 J

(b) Energy extracted from the water per second = $\frac{9450}{940}$

= 10.053…. W

= 10 W

Pump power + energy extracted from water = energy to surroundings

5 + 10 = 15 W

(c) Refrigerator coefficient of performance $= \frac{\text{heat energy extracted}}{\text{pump power}}$

$= \frac{10\text{ W}}{5\text{ W}}$

= 2