Phys. 2C(A), 11/6/19

1. Engines and Refrigerators via Energy Transfer Diagrams
   Efficiency $\eta$, Coefficient of Performance $K$

2. Some Definitions: Cycle, Reservoir

3. Connection to PV-diagrams

$\eta = \text{Efficiency} : \frac{\text{What we want}}{\text{What we have to pay for it}} = \frac{W_{\text{out}}}{Q_{\text{H}}}$
(reviced)

\[ P \rightarrow V \]

\[ P(V) = \text{constant} \]

\[ P = \frac{nRT}{V} \]

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\[ \text{Refrigerators} \]

\[ Q_H \]

\[ \text{HOT} \]

\[ \text{COLD} \]

\[ W_{in} \]

\[ Q_C \]

\[ Q_C + W_{in} = Q_H \]

\[ K = \left( \frac{\text{Coefficient of Performance}}{\text{want for it}} \right) = \frac{Q_C}{W_{in}} \]
A refrigerator has a coefficient of performance equal to 4.0. This means that, for every 1kJ that I take from the wall outlet,

A) I take out 4kJ of heat energy from the inside of the fridge.
B) I take out 5kJ of heat energy from the inside of the fridge.

An engine has an efficiency equal to 0.20. This means that, for every 1.0kJ of “waste heat” that I produce, that I have gotten ________ of work.

A) 2.0 kJ
B) 5.0 kJ
C) 0.20 kJ
D) 0.25 kJ
E) None of these
5. A refrigerator requires 200 J of work and exhausts 600 J of heat per cycle. What is the refrigerator's coefficient of performance?

\[ Q_H = 600\text{ J} \]

\[ Q_C = Q_H - W_H = 400\text{ J} \]

\[ k = \frac{Q_C}{W_H} = 2.0 \]
1) Reservoir: Large thing. @ same temp.

Cycle: Closed path on pV diagram

engine

fridge: ccw
fridge

2) $Q_{in} = |Q_1| + |Q_4|$

$Q_c = |Q_2| + |Q_3|$
Suppose you have an engine consisting of 4 steps:
1. isobaric expansion, then 2. adiabatic expansion, then
3. isobaric compression, then 4. isochoric heating.

i. Draw the process on a pV diagram.

ii. Answer the following clicker question:
Under which step(s) is heat added to the gas?

A) Step 1 only
B) Step 3 only
C) Step 4 only
D) Steps 1 and 4 only
E) Steps 3 and 4 only

iii. Give an expression for the efficiency in terms of
\( W_{\text{net, by}} \), \( Q_1 \), \( Q_2 \), \( Q_3 \), and \( Q_4 \).

\[ \eta = \frac{Q_{4U} + Q_4}{Q_1 + Q_4} \]

Also, could write
\[ \eta = \frac{(Q_1 + Q_4) - |Q_3|}{Q_1 + Q_4} = (Q_1 + Q_4) + Q_3 \]