Read 11.3

Evaluations 20%

H.W Due today midnight

Bonus H.W Available
Due Sunday midnight

Office hours 11:30 - 12:30 today

Wednesday make up Exam 7 p.m
material from all 3 exams 1, 2, 3
Length: same as midterm

Review

Heat Engines

input heat from high T Q_H

release heat at lower T Q_C

First law of Thermodynamics

$$W = Q + \Delta U$$

Engine cycle $\Delta U = 0$

Ideal Engine $W = Q$

$$W = Q_H - |Q_C|$$

Efficiency $e = \dfrac{W}{Q_H}$

Interactive Question

(C)

Which of the following statements is *not true* about a heat engine?

A) It always operates between a high temperature reservoir and a low temperature reservoir.
B) It operates in a cycle.
C) It can convert all of the input heat to useful work.
D) It conserves energy.
E) It has an efficiency given by the work done divided by the heat supplied.

Problem: A heat engine operates at 20% efficiency and does 600 J of work. What is the heat input and output of this engine?

$e = .20 \qquad w = 600\,J \qquad \text{want } Q_H,\ Q_c$

$$e = \frac{w}{Q_H} \Rightarrow Q_H = \frac{w}{e} = \frac{600\,J}{.2} = \underline{3000\,J}$$

$$w = Q_H - |Q_c|$$

$$Q_c = Q_H - w = 3000\,J - 600\,J = \underline{2400\,J}$$

Interactive Question

B

The significance of a Carnot engine is

A) all automobiles operate on the Carnot cycle.
B) it has the maximum possible efficiency of any engine. operating between the same two temperatures.
C) it violates the second law of thermodynamics.
D) it violates the first law of thermodynamics.
E) it can run at 100% efficiency.

<u>Problem:</u> A steam engine operates at a high temperature of 300 °C and a low temperature of 100 °C.

(a) What is the maximum possible efficiency?

(b) If the ~~maximum~~ possible work done by this engine is 50 KJ during each cycle, how much heat does it take in per cycle?

$T_H = 300°C + 273 \Rightarrow 573\ K$ want e, Q_H

$T_C = 100°C + 273 \Rightarrow 373\ K$

$W = 5 \times 10^4\ J$

$$e_c = \frac{T_H - T_C}{T_H} = \frac{573K - 373K}{573K} = .349 \rightarrow 34.9\%$$

$$e = \frac{W}{Q_H} \qquad e_c = \frac{W}{Q_H} \text{ maximum}$$

$$Q_H = \frac{W}{e_c} = \frac{5 \times 10^4\ J}{.349} = \boxed{1.4 \times 10^5\ J}$$

Interactive Question

(D)

You are taking bids to have a heat engine built that will operate between 200°C and 30°C. Different contractors claim the efficiency of their engines as:

A) 100%
B) 80%
C) 40%
D) 30%
E) 20%

Which contractor would you accept the bid from?

Problem: A 100 hp car operates at 15% efficiency. Assume the engine's water temperature of 85 C is its low temperature and the intake temperature of 500 C is its high temperature.

(a) How much does this efficiency differ from the maximum possible efficiency?

(b) What is the heat input into this engine per hour?

(c) What is the work done by this engine per hour?

(d) What is the heat output per hour?

$e = .15$ $\quad P = 100\,hp$ $\quad$ want e, e_c

$T_H = 500°C \rightarrow 773\,K$ $\quad Q_H, W, Q_C$

$T_C = 85°C \rightarrow 358\,K$ $\quad t = 1\,hour \Rightarrow 3600\,s$

a) max effic $\quad e_c = \frac{T_H - T_C}{T_H} = \frac{773 - 358}{773\,K} = .537$ or 53.7%

want $\frac{e}{e_c} = \frac{.15}{.537} = .28$ $\quad$ 28% of maximum

b) $P = (100\,hp)\left(\frac{746\,W}{hp}\right) = 7.46 \times 10^4\,W$

power $= \frac{\text{Energy}}{\text{time}} = \frac{Q_H}{t} \Rightarrow Q_H = Pt$

$7.46 \times 10^4\,W \cdot 3600\,s = Q_H = 2.69 \times 10^8\,J$

c) $e = \frac{W}{Q_H}$ $\quad W = e\,Q_H = (.15)\,2.69 \times 10^8\,J = 4.04 \times 10^7\,J$

d) $Q_C = Q_H - W = 2.69 \times 10^8\,J - 4.04 \times 10^7\,J$

$2.29 \times 10^8\,J$