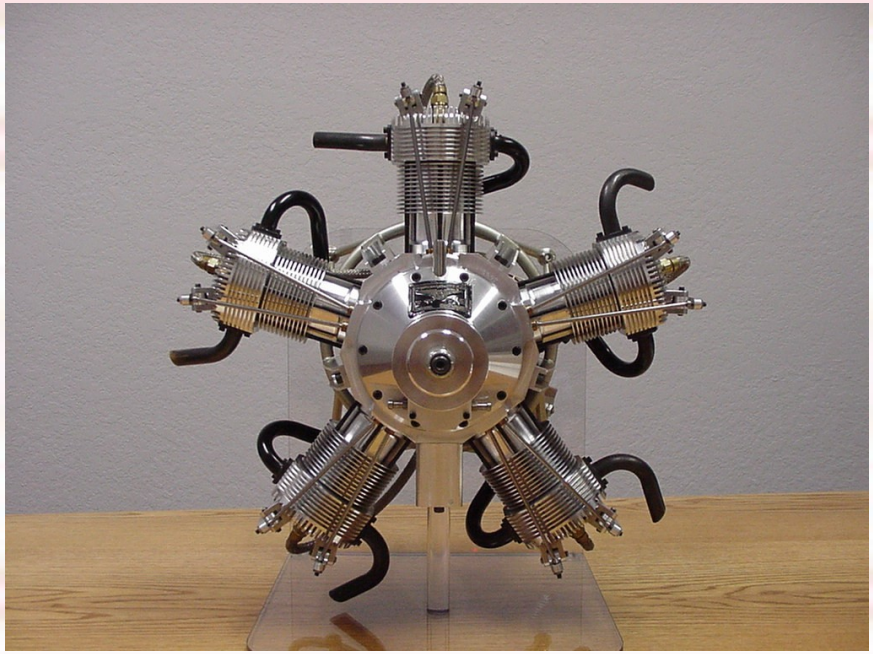
Introduction to Thermodynamics And Applications



Physics 420

Patrick Lawrence

Topics

- Confusion about Heat, Internal Energy and Temperature
- Methods of heat transfer
- The Ideal Gas Law
- Compression
- Applications of Thermodynamics

Intro to Thermo

What is thermodynamics??

Thermo: Simple means **HEAT** (or Energy)
Dynamics: Movement

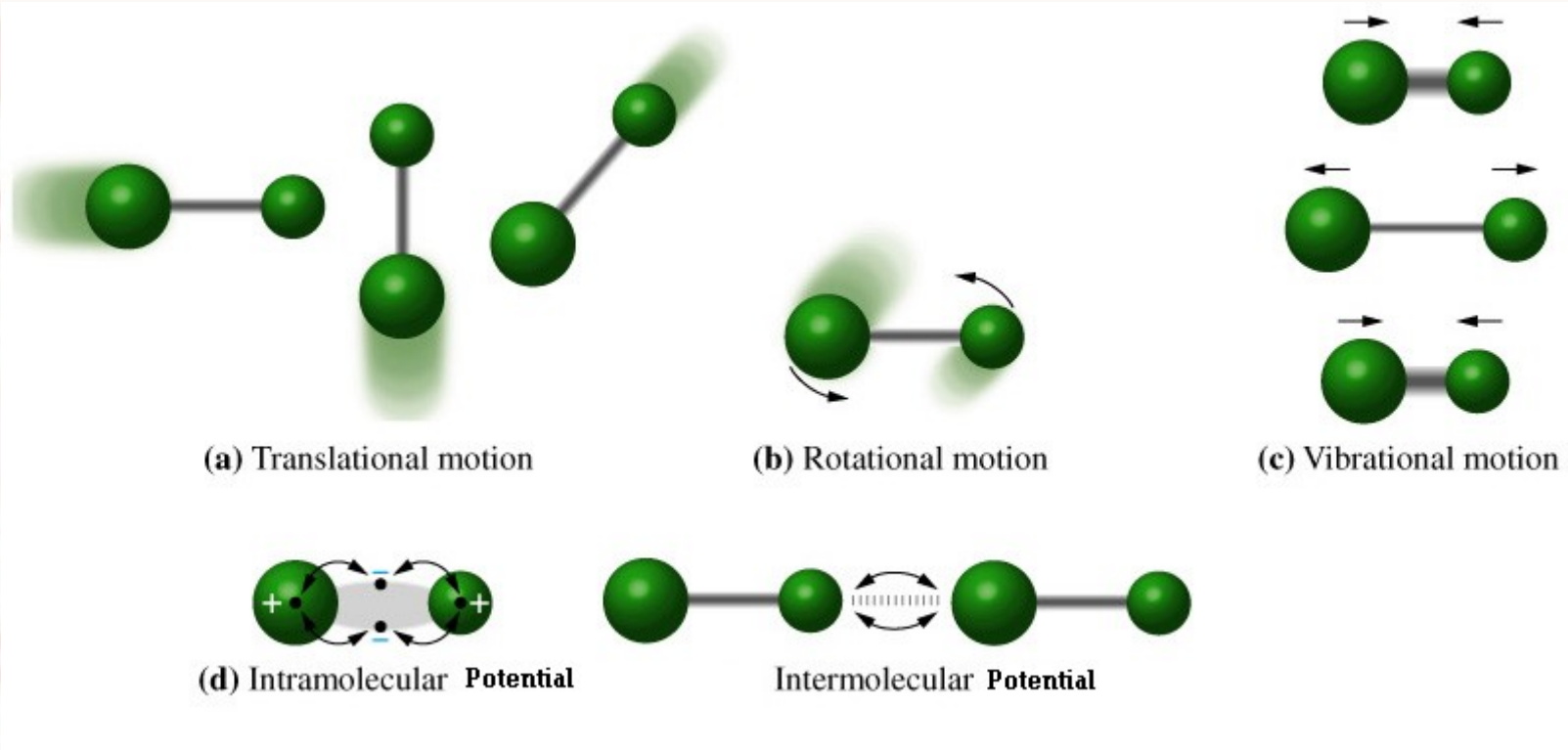
This implies that thermodynamics is the movement of energy!!

Heat and Temperature

In physics we are commonly interested in the movement of energy. This is useful because energy is neither created or destroyed.

Heat refers to neither a substance nor energy heat is actually a measurement of the **movement of energy**

Internal Energy



Internal energy is the energy associated with the RANDOM motion of molecules and how they interact. The commonly used symbol is U.

Temperature

- Temperature is indicator of direction for heat flow. It doesn't refer to the internal thermal energy of a system.

- Temperature describes the tendency of an object to give up energy to it's surroundings.

- An object at a higher temperature will give off thermal energy to a lower temperature object.

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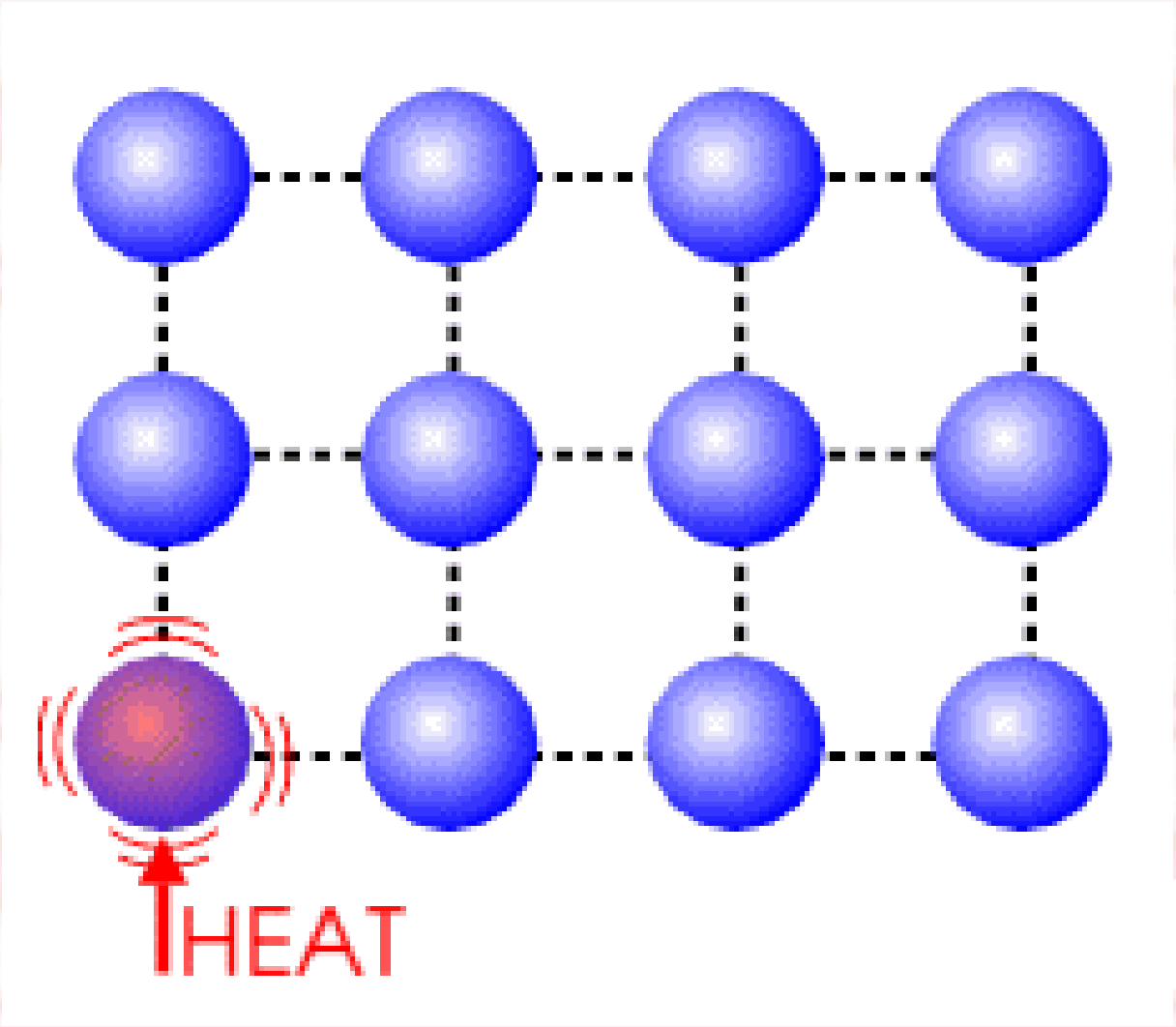
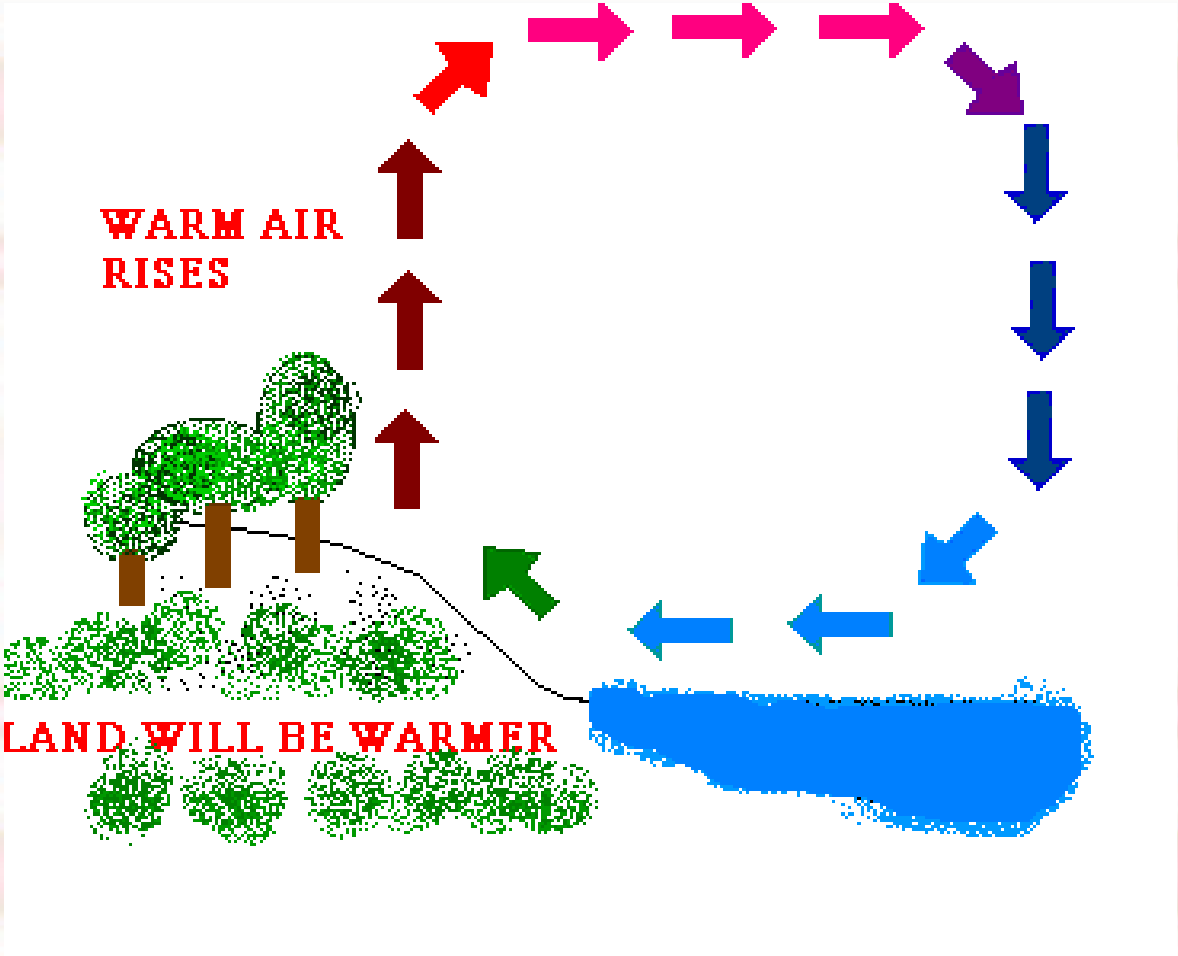
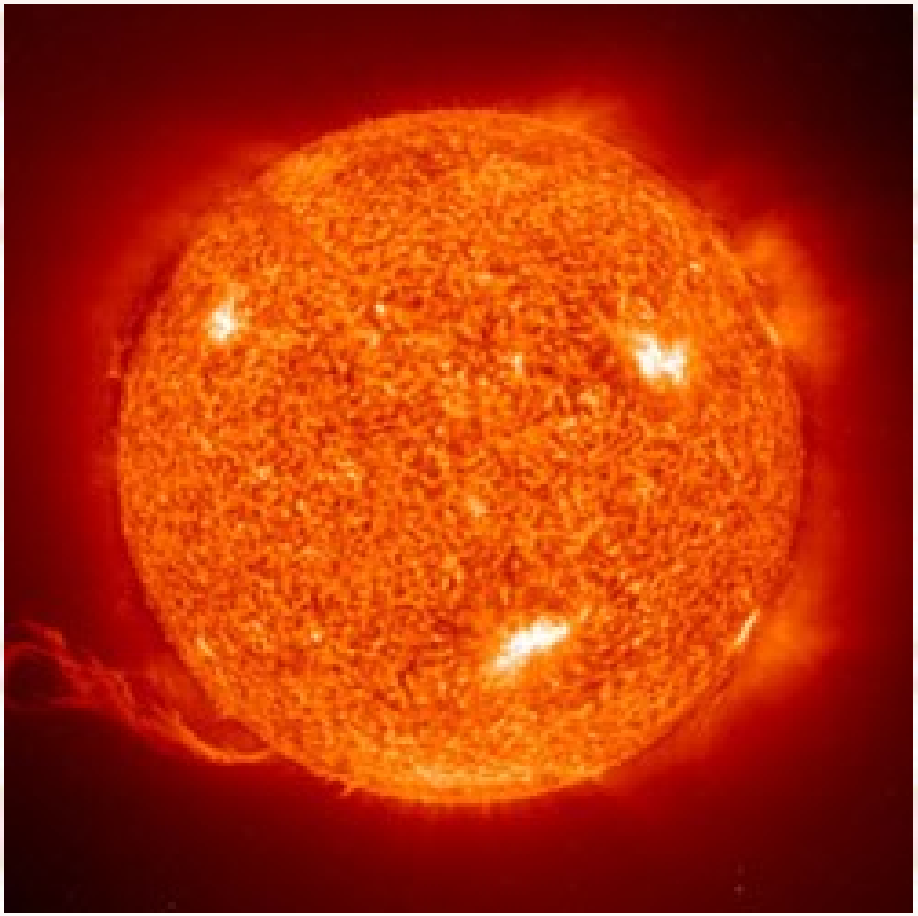
Conduction



Convection



Radiation



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The Ideal Gas Law

PV= n RT OR PV= N kT

Describes the state of an ideal gas. This is called the ideal gas law because gases don't behave according to this equation when they are at high temperature or pressure. However it is useful for a wide range of applications.

Laws of Thermodynamics: According to C.P. Snow

1st Law: You can't win!!!

2nd Law: You can't break even!!!

3rd Law: You can't get out of the game!!!

Laws of Thermodynamics

1st Law: Energy can neither be created or destroyed.

$$\Delta U_{System} = Q + W$$

This means that we can never get more out of a system then what we put into it. Hence

"YOU CAN'T WIN" !!

Laws of Thermodynamics

2nd Law:

1) Heat flows from a hot object to a colder object.
2) A given amount of heat can not be changed complete into energy to do work.

Even though you put a certain amount of energy into a system you can't actually get that energy back as work.

"YOU CAN'T BREAK EVEN"

Laws of Thermodynamics

3rd Law: The energy of a system tends towards a constant as absolute zero is approached. (Entropy approaches a constant)

Or Stated another way:

You can't reach absolute zero. You can't remove all the energy from a system.

YOU CAN'T GET OUT OF THE GAME!!!

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Isothermal Compression

Isothermal Compression – Temperature doesn't change during a compression.

PV = NkT, V decreases and everything else stays the same. But if the volume decreases according to the ideal gas law temperature be decrease also???

T= PV/Nk

HEAT FLOWS INTO THE SYSTEM!!

Adiabatic Compression

Adiabatic Compression – No heat escapes or is introduced to the system while compression is occurring.

No heat flows either in or out of the system. But then what happens to the internal energy?

$$U = Q + W$$

Isothermic Compression $\Delta T = 0$

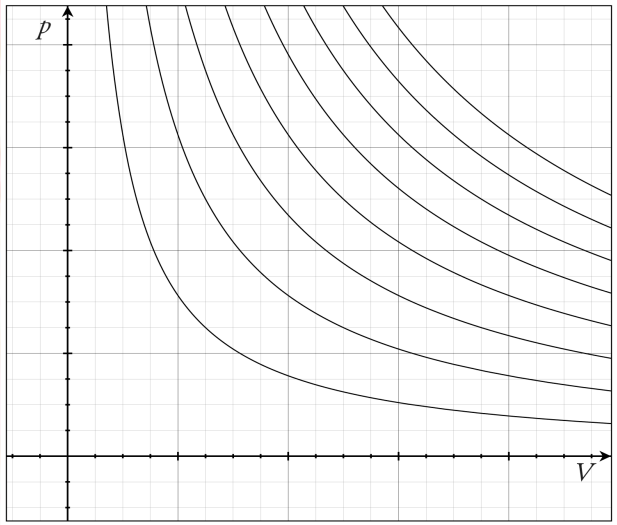
and

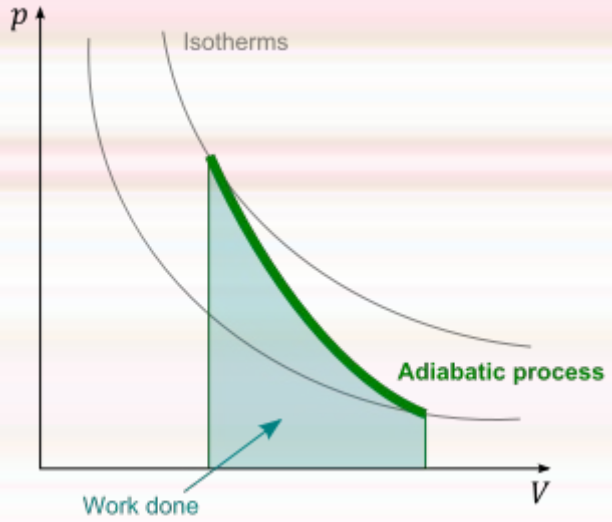
Adiabatic Compression Q =0

$$Q = 0 \quad \Delta U = W$$

So if you have expansion work being done the internal energy drops. But if the system having work done on it (W positive) the internal energy increase.

P-V Diagrams





Isotherms connect two points of equal temperature. These lines all obey the constraint PV = Constant.

Adiabatic lines connect isotherms together.

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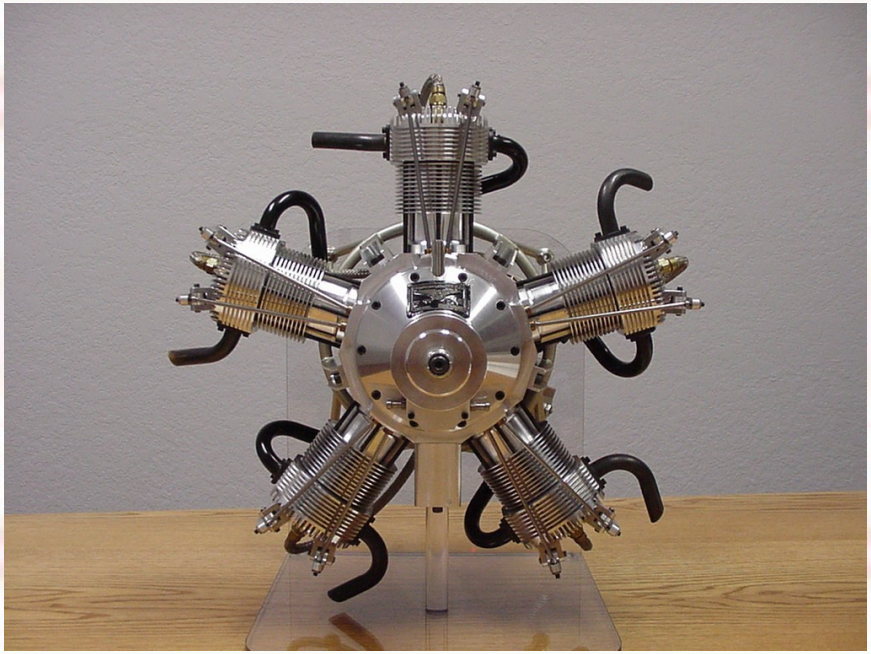
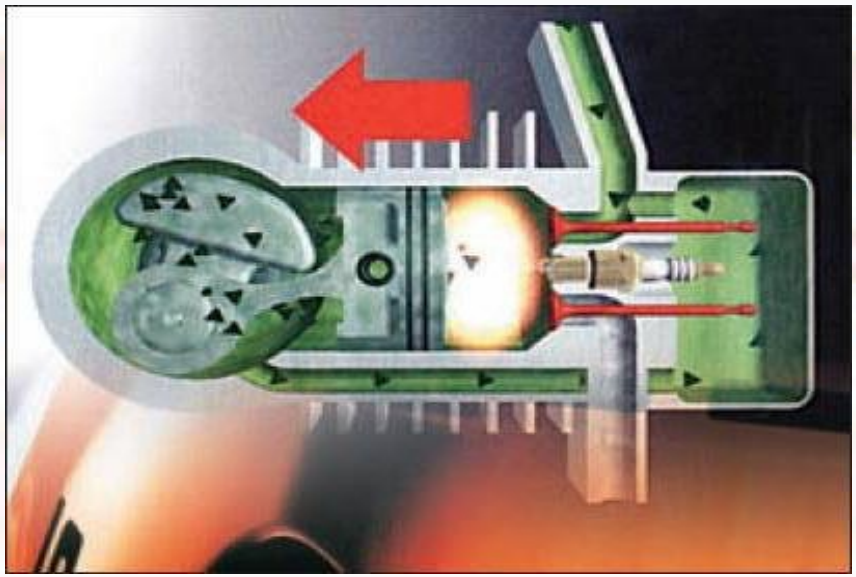
Engines



But engines just involve a little explosion and a series of pistons being pushed back a forth. Then the heat is lost through the exhaust. Doesn't seem to have much to do with thermodynamics does it? Okay the cooling system on a engine could involve thermodynamics but that is kinda minor factor why get a degree in physics to fix a cooling system.

Engines in more detail

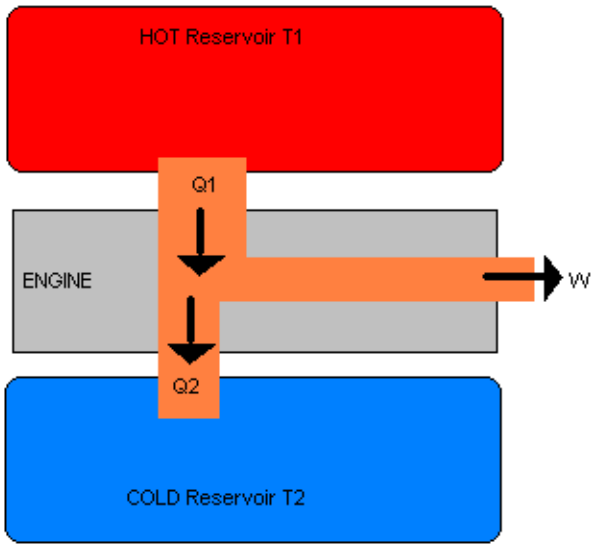


At a closer look what is doing the pushing of a piston?

An Exploding gas pushes the engine but is that a thermo-dynamic process?

Well kinda!! The explosion is a chemical prop-erty but what happens as a result of the explo-sion is a thermodynamic property. Recall the ideal gas law PV = N KT. This formula contain some key information that allows engines to work.

Heat Engines



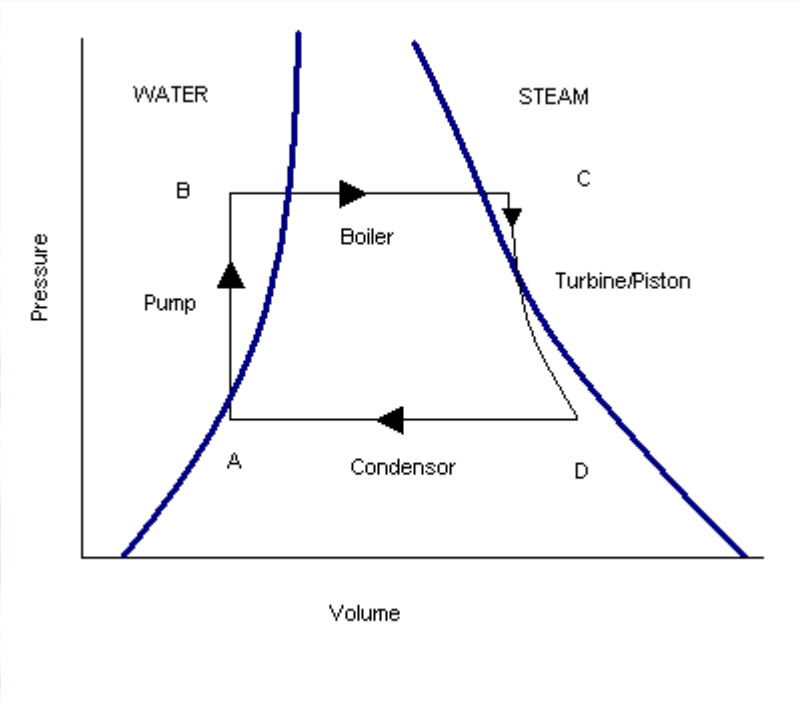
- A heat engine is a device that converts heat to usable energy.
- Heat is absorbed from a hot reservoir and expelled to a cold reservoir.

The First Steam Engine

The first steam engine was created in 1st century AD by the Hero of Alexandria and was know as a aeolipile. But after that forgotten until 1680 when Denis Papin built a steam powered device.

The Steam Engine

The steam engine uses a cycle know as the Rankine Cycle.



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