Chapter 10

- Thermodynamics

Heat and Work

- Heat can be used to do work.
- Energy transferred to heat turns water into steam which then exerts a force on a turbine and does work.

Work Equation

- Work = Pressure x volume change
- $W = P \times \Delta V$
- Volume = Area x distance (cylinder)
- Work is in Joules (J)

$W = V \times (P_f - P_i)$

- A gas has a volume of 20 and starts with a pressure of 1900. If it does 20 J of work, what is the final pressure?

Isovolumetric Process

- No work is done if the volume is not changed (to have work you must have movement)

Isothermal Process

- When the system’s temperature remains constant and the internal energy does not change.
- Pressure can change but not temperature.

Adiabatic Process

- A thermodynamic process during which work is done but no energy is transferred as heat.
- $Q = 0$
- No heat can be lost because there is usually not enough time in the process. (It happens to quickly for heat to escape)

1st Law of Thermodynamics

- The principle of energy conservation that takes into account a system’s internal energy as well as work and heat is called the first law of thermodynamics.

1^{st} Law Equation

- $\Delta U = Q - W$
- The Q and W can be positive or negative depending on circumstances.
- Q = + if energy is added
- Q = - if energy is removed
- W = + if work is done **by** the system
- W = - if work is done **on** the system

$$\Delta U = Q - W$$

- 10 J of heat is removed from system while the system does 30 J of work. How much internal energy does the system have?

Cyclic Process

- A thermodynamic process in which a system returns to the same conditions under which it started is called a cyclic process.
- For example, a refrigerator energy is transferred in four steps. However, the process restarts each time under the same conditions. - no loss or gain of energy

Heat Engines

- Heat engines use heat to do work.
- $W_{net} = Q_h - Q_c$
- Q_h = heat added
- Q_c = heat removed

$$W_{net} = Q_h - Q_c$$

- If a steam engine takes in 2200 J from a boiler and gives up 1500 J in exhaust during one cycle, how much work is being done each cycle?

Gas Engine - Steps

- Step 1: Spark plug fires.
- Step 2: Gas is ignited.
- Step 3: Gas creates pressure.
- Step 4: Pressure moves Piston.
- Step 5: Piston moves crankshaft.

2^{nd} Law of Thermodynamics

- No cyclic process that converts heat entirely into work is possible.
- In other words, some energy must always be transferred as heat to the environment.
- Cannot be 100% efficient!

Efficiency Equation

- $Eff = W_{net} / Q_h$
- $Eff = (Q_h - Q_c)/Q_h$
- $Eff = 1 - (Q_c/Q_h)$

If a steam engine takes in 2200 J from a boiler and gives up 1500 J in exhaust during one cycle, how efficient is it?

Entropy

- Entropy is the measure of a system’s disorder.
- In general, it is believed that without interference, disorder is more likely than order.
- The greater the system’s disorder, the greater the system’s entropy.

- Greater disorder or entropy means there is less energy to do work.
- Imagine atoms in an engine bouncing around chaotically compared to atoms all bouncing (pushing) in the same direction. The ordered atoms will accomplish more work.

THE END OF THE UNIVERSE!

- Since everything in the world is moving towards chaos, it has been suggested that eventually the entire world will reach a maximum value of entropy (chaos).
- At that time, the universe will reach a state of thermal equilibrium and the temperature will be the same everywhere.
- Since there will be no temp difference, no heat can be transferred and thus no work can be done.
- This is called ultimate "heat death" of the universe and is predicted to happen in 100 trillion years. So make your plans now!

Assignment

- Unit 10 Worksheet