Heat Engines

How can an automobile run on thermal energy?
  Doesn’t the second law forbid this conversion?
  Doesn’t burning destroy gasoline’s order completely?

An automobile engine is a “heat engine”

A heat engine diverts some heat as it flows naturally from hot to cold and converts that heat into useful work
  Natural heat flow increases entropy
  Converting heat to work decreases entropy

Overall, some heat can become work without decreasing entropy
Heat Pumps

A heat pump transfers some heat from cold to hot, against the natural flow, as it converts useful work into heat
   Reverse heat flow decreases entropy
   Converting work to heat increases entropy

Overall, some heat can flow from cold to hot without decreasing entropy

Efficiency

How efficient can an automobile engine be?
What fraction of thermal energy can become work?

Heat engines and pumps are limited by 2nd law
   They cannot decrease the world’s overall entropy
   Their efficiencies depend on temperature differences

As the temperature difference increases,
   a heat pump becomes less efficient
   a heat engine becomes more efficient
Internal Combustion Engine

How is an automobile engine a heat engine?

An internal combustion engine burns fuel and air in an enclosed space to produce hot burned gases.

As it allows heat to flow to cold outside air it converts some heat into useful work. Uses that work to propel a vehicle.

Four Stroke Engine

- **Induction Stroke**: fill cylinder with fuel & air
- **Compression Stroke**: squeeze mixture
- **Power Stroke**: burn and extract work
- **Exhaust Stroke**: empty cylinder of exhaust

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**Induction Stroke**

Engine pulls piston out of cylinder

Low pressure inside cylinder

Atmospheric pressure pushes fuel and air mixture into cylinder

Engine does work on the gases during this stroke
**Compression Stroke**

Engine pushes piston into cylinder

Mixture is compressed to high pressure and temperature

Engine does work on the gases during this stroke

**Power Stroke**

Mixture burns to form hot gases

Gases push piston out of cylinder

Gases expand to lower pressure and temperature

Gases do work on engine during this stroke
Exhaust Stroke

Engine pushes piston into cylinder

High pressure inside cylinder

Pressure pushes burned gases out of cylinder

Engine does work on the gases during this stroke

When you put a hot metal rod in cold water, the overall entropy (the measure of disorder)

(A) remains constant because no work is done.

(B) remains constant because entropy is conserved.

(C) decreases.

(D) increases.
Your home is heated by a heat pump that transports heat from the outdoor air to the indoor air. As this device operates,

(A) it delivers more heat to the indoor air than it removes from the outdoor air.

(B) the thermal energy it delivers to the indoor air is equal to the electric energy it consumes.

(C) it delivers less heat to the indoor air than it removes from the outdoor air.

(D) it delivers the same amount of heat to the indoor air as it removes from the outdoor air.