Science 10 Unit B: Physics

Efficiency and Energy Conversions in Technology

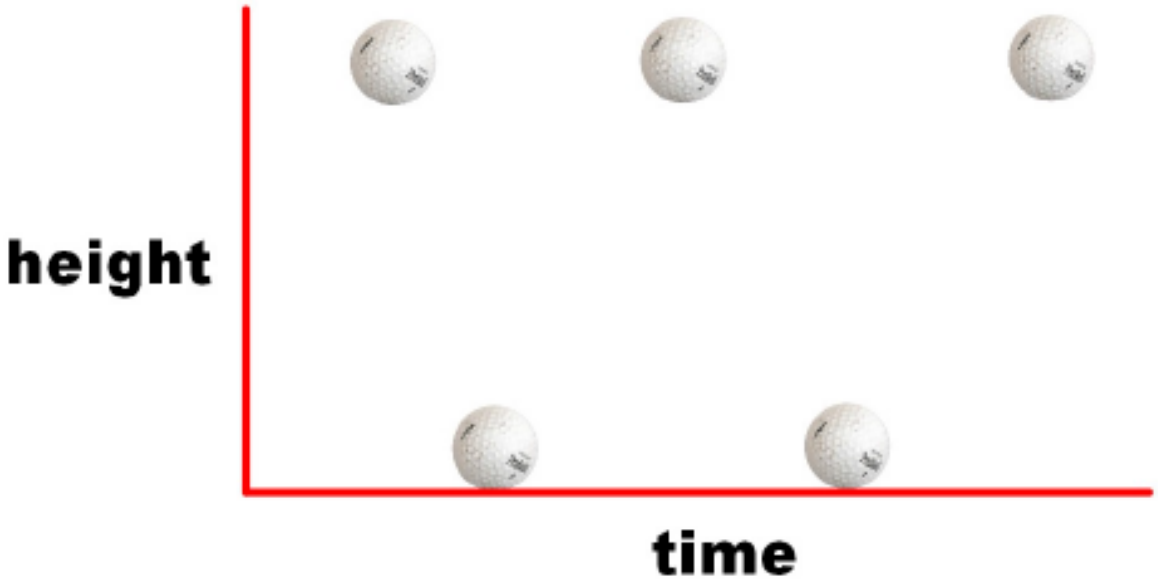
Recall from previously the

The Law of Conservation of Energy

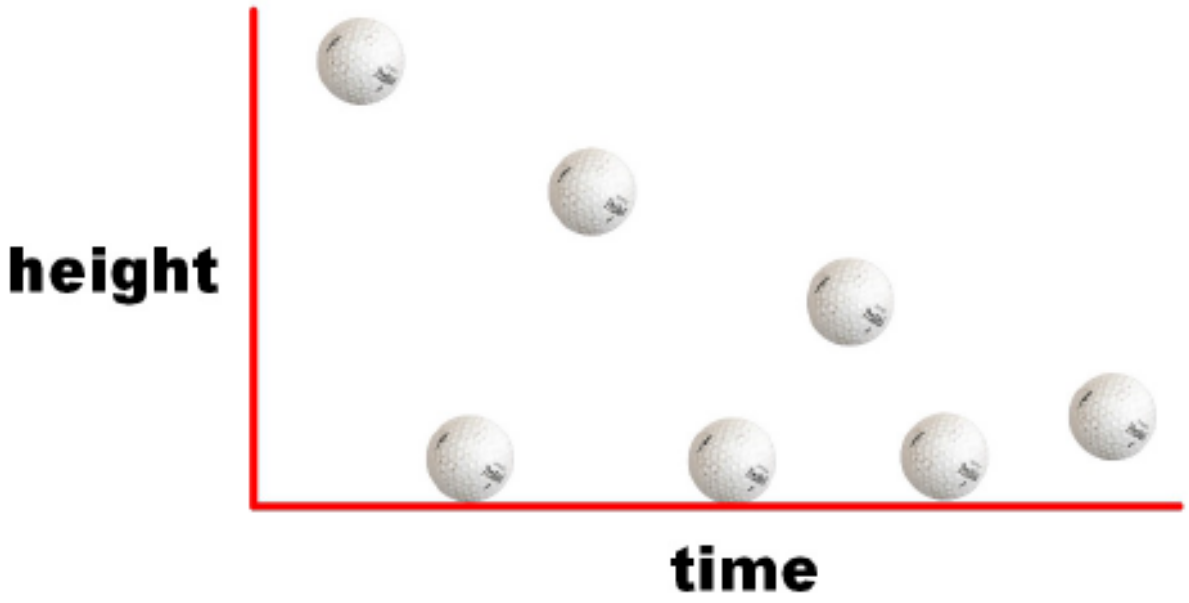
- energy cannot be created or destroyed
- the total energy of a system is always the same

We had said this means energy is never "lost". However, it doesn't mean that when an energy change takes place, all of the energy converts into a useful type. Sometimes, some of this energy is converted to a form we just can't use.

For example, if you drop a golf ball from 1 m in the air, it should hit the ground and bounce back to 1 m in the air. The PE is converted to KE, then back to PE, over and over again.



What really happens is some of the total energy is lost during each energy conversion.



Where does some of the energy go as a golf ball hits th ground?

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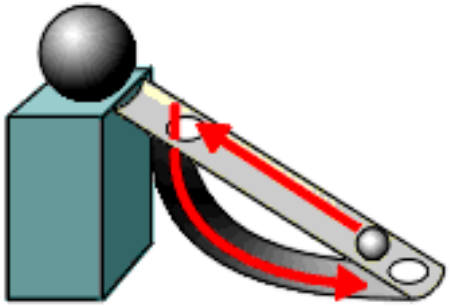
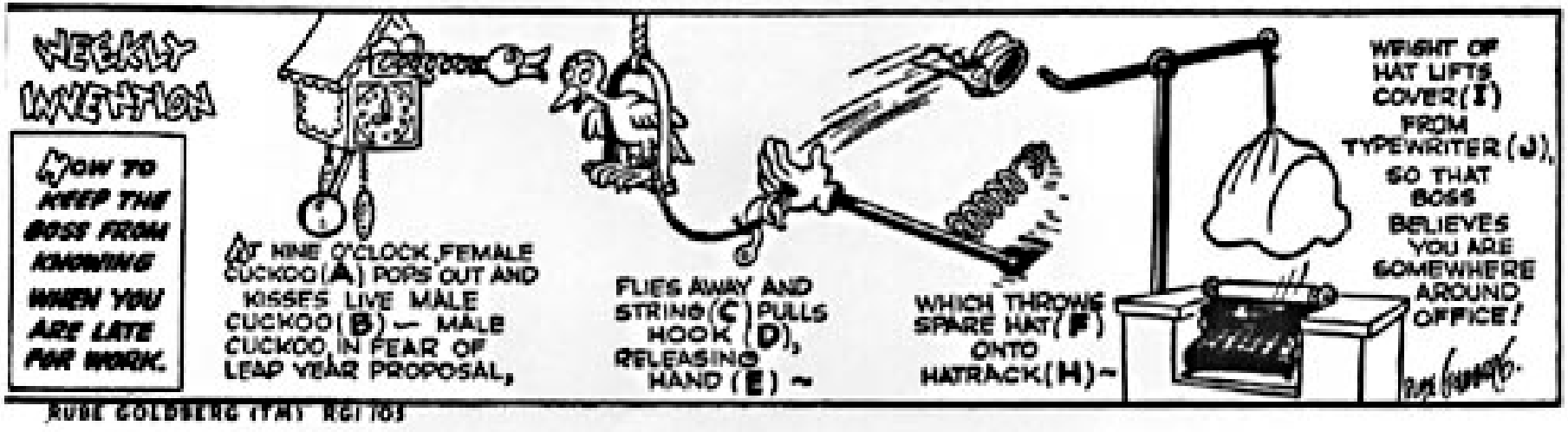
B3.1 Laws of Thermodynamics





1st Law of Thermodynamics

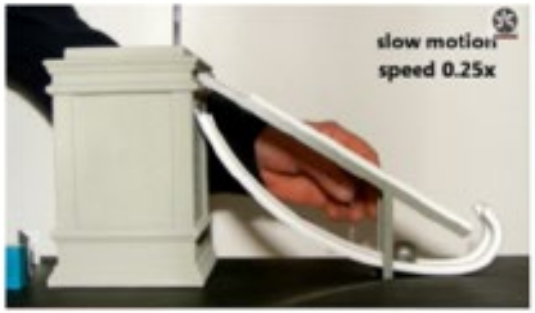
- Energy cannot be created nor destroyed, only converted from one form to another
- Example: Flashlight → chemical → electrical → light + heat energy
- The total energy of a system is always conserved

2nd Law of Thermodynamics

- Heat energy always flows from hot to cold objects
- In every type of energy conversion, some energy is converted to thermal energy
- We say energy is “lost” because it is not useful to do work (example: heat produced by engine)
- Since some energy is always lost, no machine is 100% efficient at converting energy to useful forms

Ideally, we would build a machine that was 100% efficient in its energy conversions. However, this is not possible.

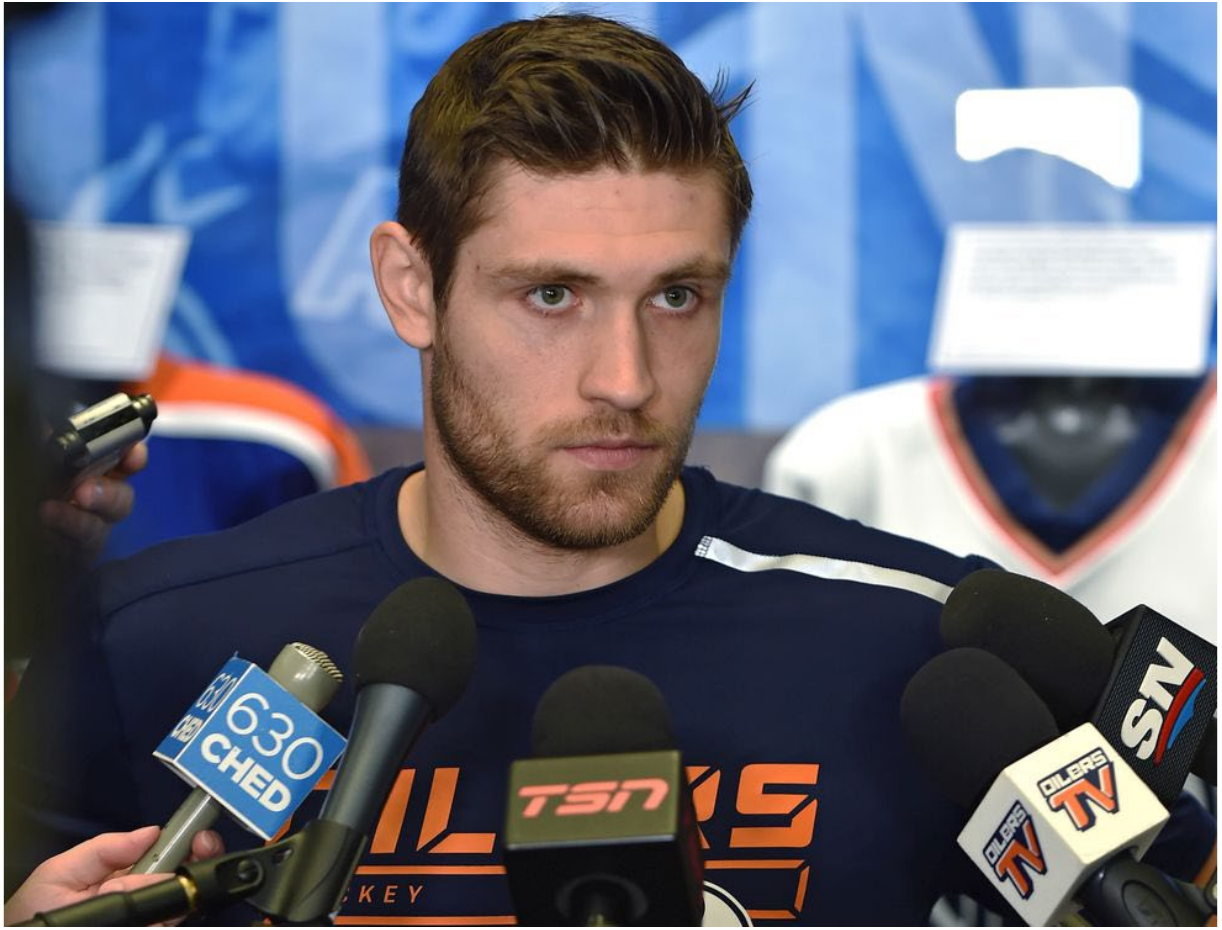
The Laws of Thermodynamics state that no machine can be 100% efficient. Energy is always converted to friction, light, heat, some sort of "non useful" form.



http://www.youtube.com/watch?v=V70w3cxDJIM

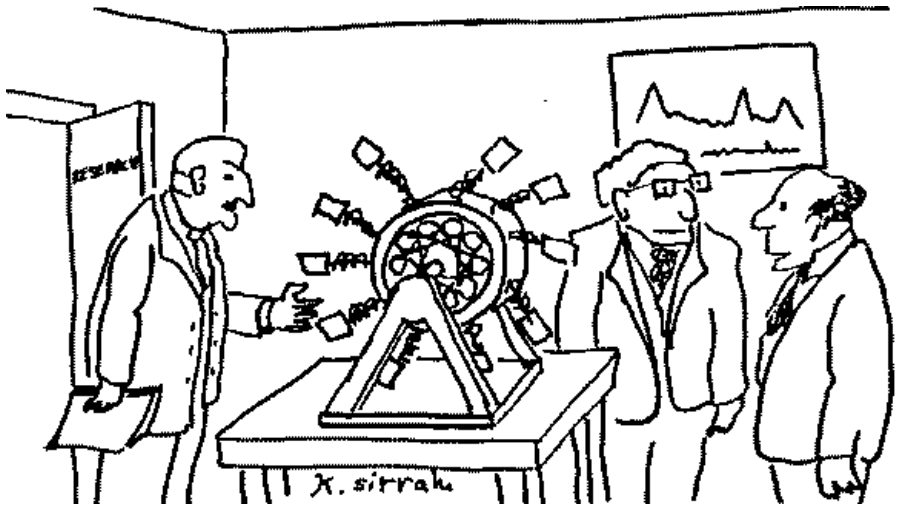
http://www.youtube.com/watch?v=287qd4ul7-E

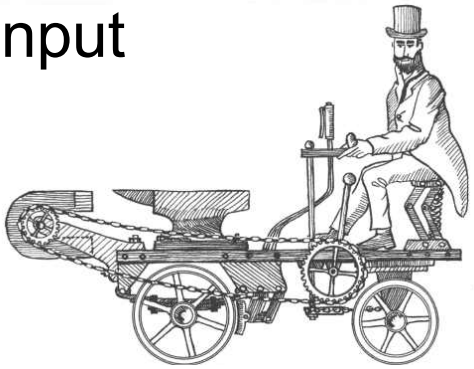
Theoretical (and not possible) machines that are 100% efficient are called perpetual motion machines.

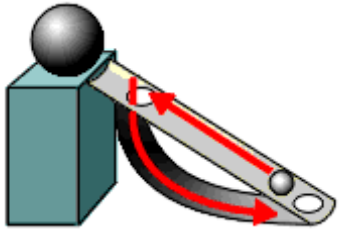


Sorry, Leon. That means you didn't actually give 110% in that game last night...

- People have attempted to create the perfect machine called a **perpetual motion machine** in which 100% of the input energy is converted to mechanical energy
- Once energy was added to the machine, it could operate indefinitely.
- Since no machine is 100% efficient, it is useful to calculate how efficient a machine is
- The formula % Efficiency = $\frac{\text{useful energy output}}{\text{total energy input}}$ X 100%



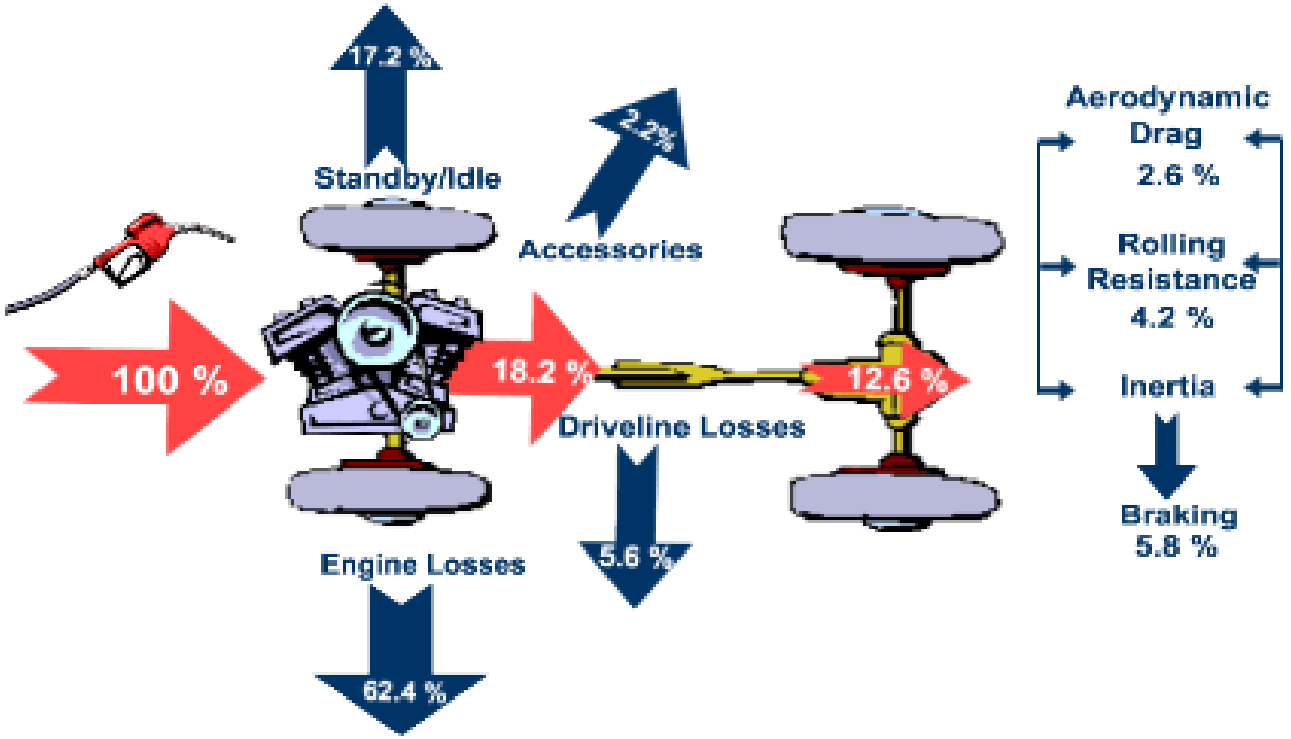




"It may be perpetual motion, but it will take forever to test it."

B3.3 Useful Energy and Efficiency

Pages 215-220



Useful Energy

- The purpose of any machine is to convert an **energy input** into a useful **energy output** which is used to do work
  - **Example: a flashlight converts potential chemical energy from a battery into light and heat energy**
- No machine is 100% efficient. Some energy will be converted to wasted energy (eg friction of pistons of engine, heat in above example)

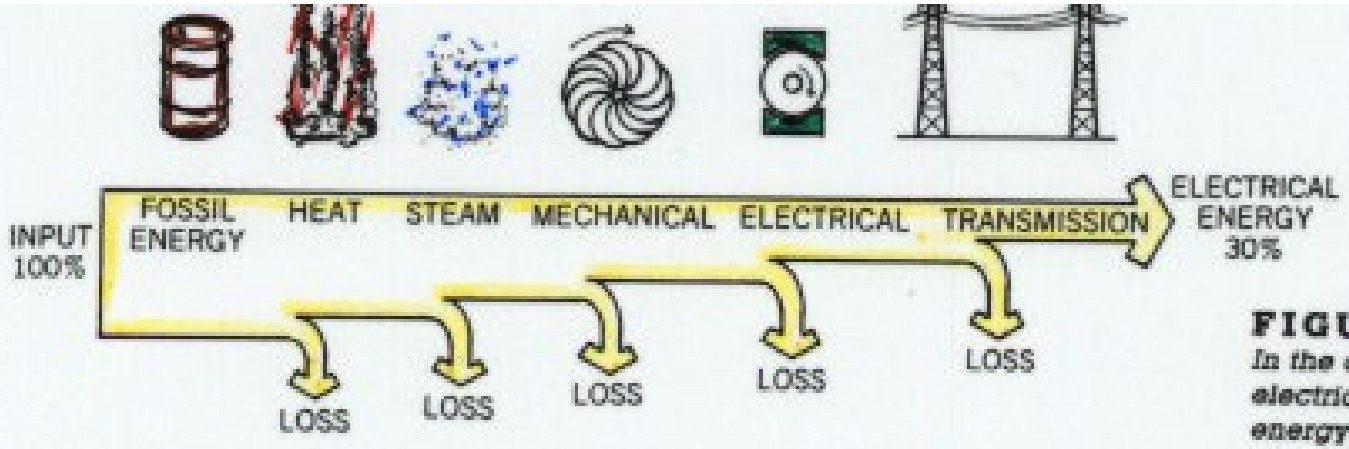


FIGURE 2.19
In the conversion of fossil fuel into electricity about 70% of the original energy is lost.

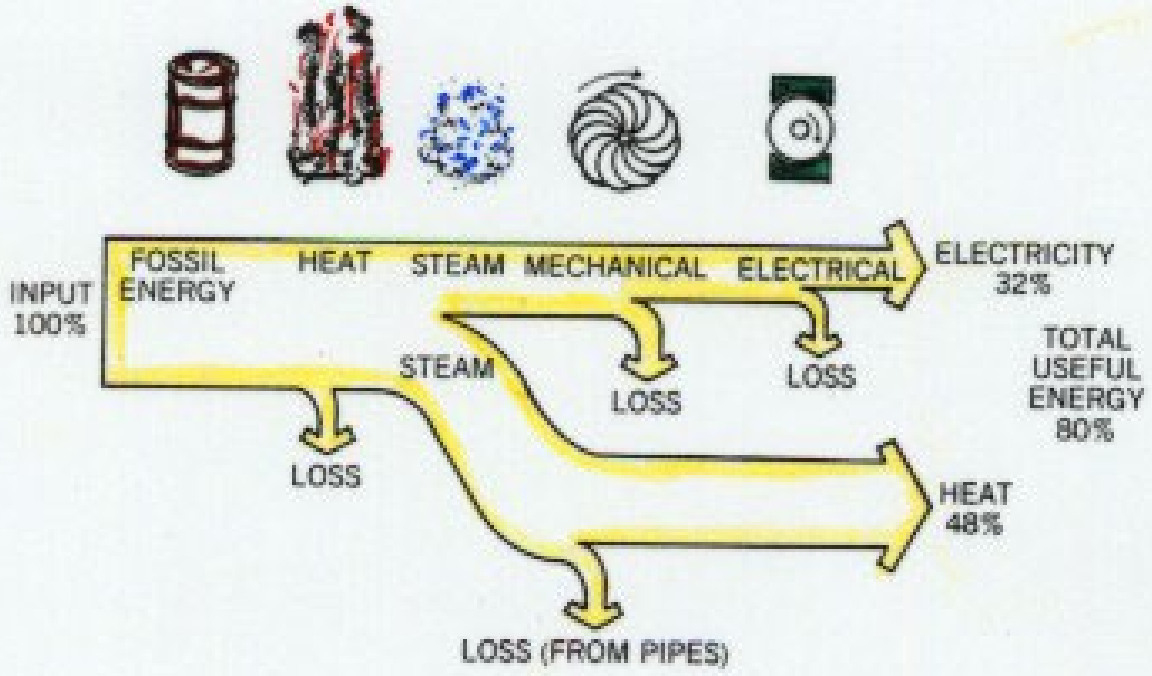
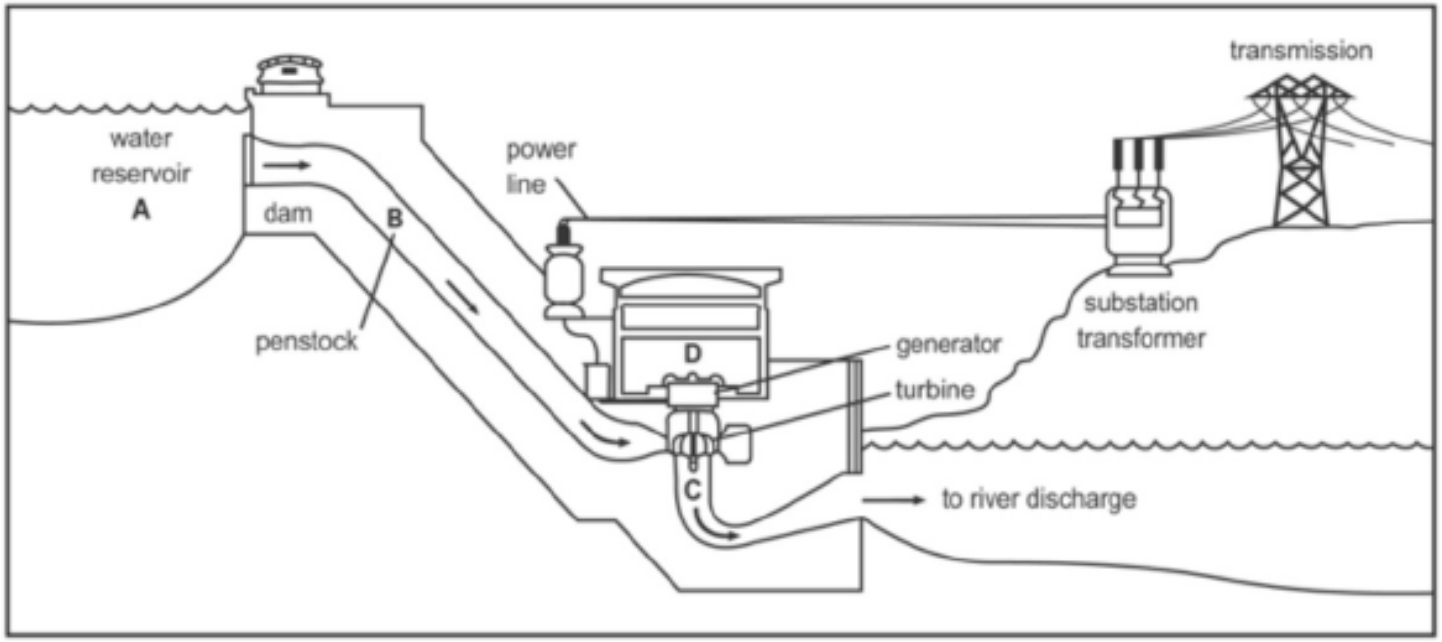


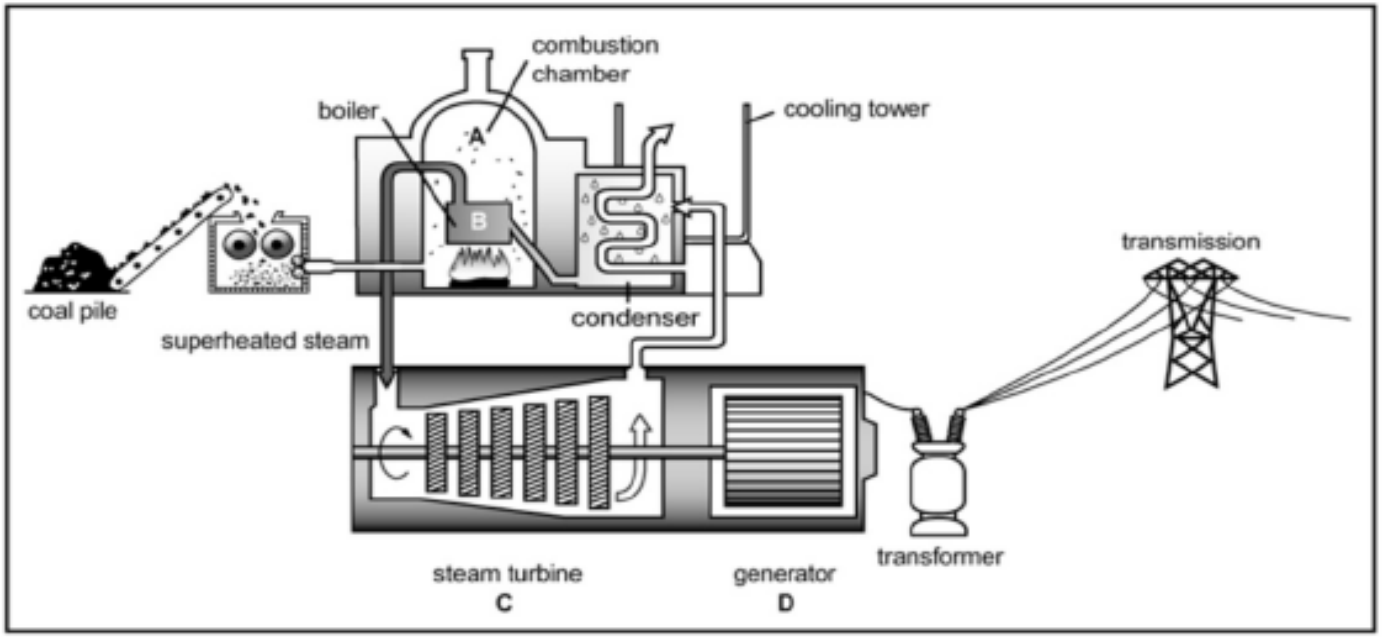
FIGURE 2.20a
Because cogeneration (total energy) systems generate electricity at the building site, they are able to utilize much of the heat normally wasted.

Hydro-electric Power Station



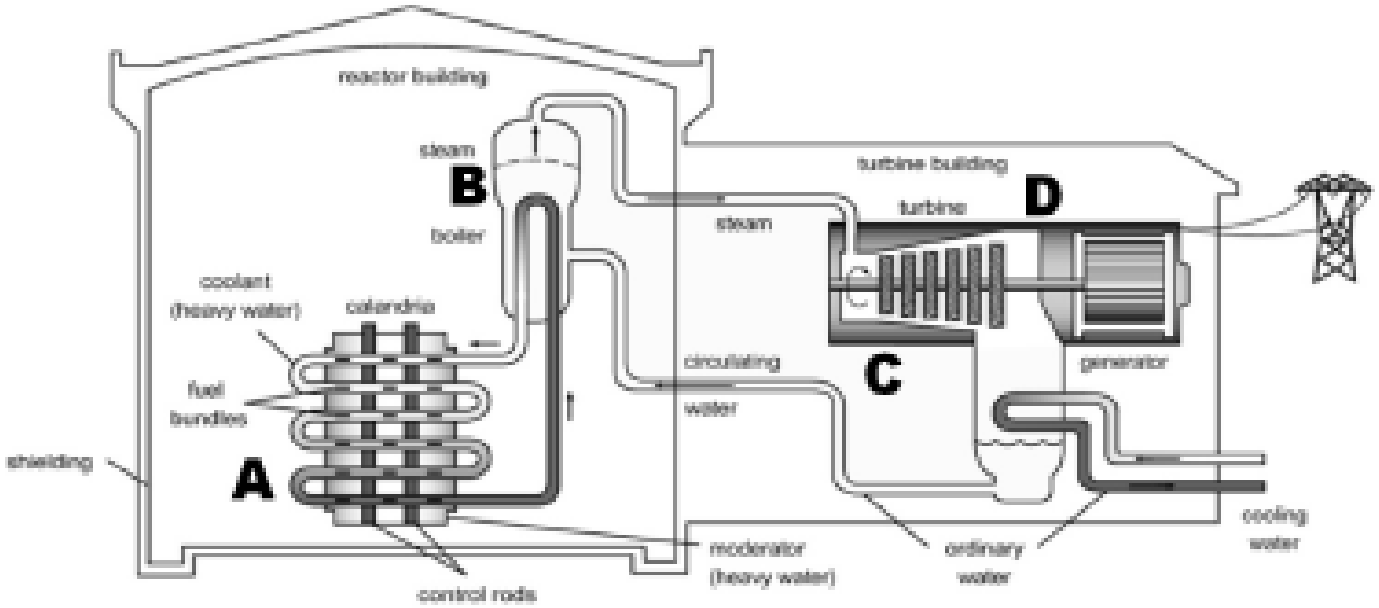
Energy Conversions:

Coal-burning Power Station



Energy Conversions:

Nuclear Power Station



Energy Conversions:

Efficiency

- Measures how effectively a machine converts **energy input** to **useful energy output**
- To Calculate Efficiency:

$$\% \text{ Efficiency} = \frac{\text{Useful Energy Output}}{\text{Total Energy Input}} \times 100\%$$

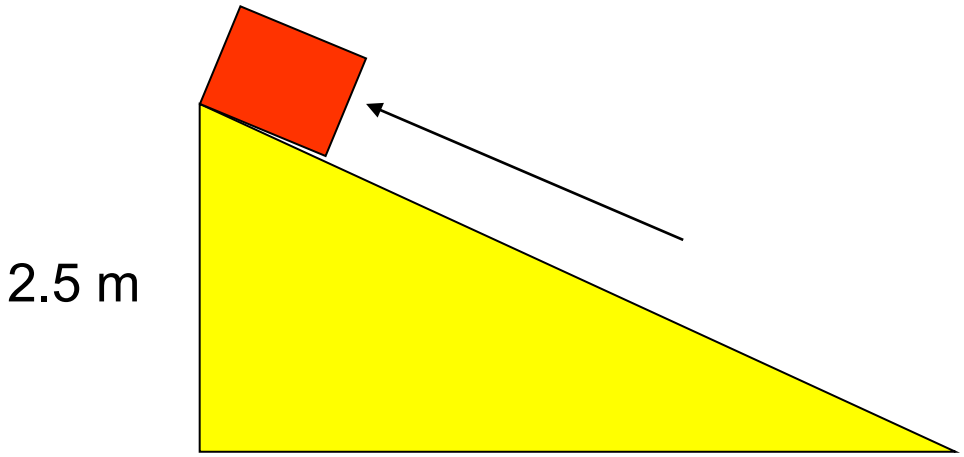
- Note: Work may be substituted for Energy

ex) An automobile's engine consumes 2500 kJ of chemical energy from gasoline, but only 325 kJ is turned into kinetic energy. What is the percent efficiency of the engine?

ex) A hand-crank electric generator energy is 95% efficient. How much kinetic energy has to be cranked into the generator to produce 300 J of energy?

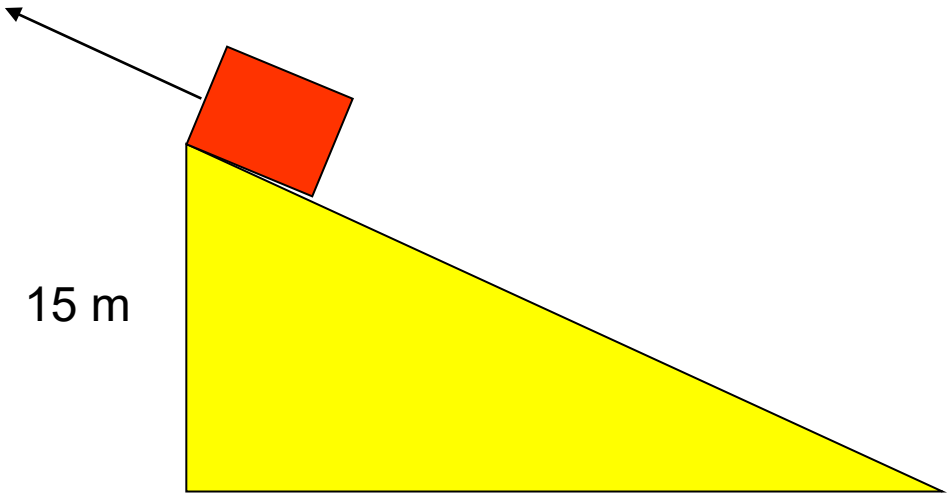
Examples:

1) It takes 820 J of work to drag a 15 kg box to the top of a 2.5 m high ramp. Calculate the efficiency of the ramp.



Example 2

A 100 kg load was pulled at a constant speed up a ramp to a height of 15 m by a force of 1120 N. Calculate the % efficiency of the ramp.



Example 3

- A small motor has an efficiency of 85%. In lifting the load, it produces 15 J of mechanical energy input. Calculate the useful mechanical energy output of the motor. (13J)