Energy and Society

Physics 20051
Energy 20101
Society Technology and Values 20304

Professor Ani Aprahamian
Help with the homework

Wednesday
2pm - 3pm in 113b NSH    Mallory Smith

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Can be flexible if you email....
Part I of this course (chapters 1-4)

- Production of Energy
- Loss of Energy
  - Efficiency
  - Heat (friction, convection, evaporation, etc)
  - 2nd law of Thermodynamics
  - Refrigeration/heat pumps
Part I of this course

• What is the origin of Earth?
• How old? Life?
• Population of earth now?
• Energy Use: Power
  – Work, Energy, Power (units)
  – Potential Energy, Kinetic Energy
  – Generation of Electricity- Electric and Magnetic Fields
  – Electromagnetic Radiation
Part II of this course (chapters 5-6)

• Production of Energy from Fossil Fuels
• Energy content
  – Coal
  – Natural gas
  – Oil (gasoline, diesel, etc)
• Pollution...\( \text{CO}_2 \), particulate, other (sulfur, nitrogen oxides, heavy metals, etc)
Total energy flow in the US: in Quads of BTU

Renewable energy resources
- solar energy
- wind
- geothermal
- hydropower
Fossil Fuels
Coal
Natural gas
Oil

Nuclear Energy?

Renewable energy resources
Solar energy
Wind
Geothermal
Hydropower
## Conversions...

<table>
<thead>
<tr>
<th></th>
<th>joule</th>
<th>watt hour</th>
<th>electronvolt</th>
<th>calorie</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 J = 1 kg·m² s⁻²</td>
<td>1</td>
<td>2.778 × 10⁻⁴</td>
<td>6.241 × 10¹⁸</td>
<td>0.239</td>
</tr>
<tr>
<td>1 W·h =</td>
<td>3600</td>
<td>1</td>
<td>2.247 × 10²²</td>
<td>859.8</td>
</tr>
<tr>
<td>1 eV =</td>
<td>1.602 × 10⁻¹⁹</td>
<td>4.45 × 10⁻²³</td>
<td>1</td>
<td>3.827 × 10⁻²⁰</td>
</tr>
<tr>
<td>1 cal =</td>
<td>4.1868</td>
<td>1.163 × 10⁻³</td>
<td>2.613 × 10¹⁹</td>
<td>1</td>
</tr>
</tbody>
</table>
How many megajoules are in 1 exajoule?

joules are energy
Mega =
Exa =

How many petagrams in 1 gigatonne?

Peta =
Giga =
Tonnes =

How many kilowatt hours in 1 gigawatt-hr?
**Energy** is the ability/capacity to do work

**Work** is the transfer of energy

$1 \text{ J} = 1 \text{ N m}$

A force of 1 N moving a body over 1 m does 1 J of work.

**Power** = the rate at which work is performed.
How is friction different than gravity?

If you apply a force on an object to move it along a surface…. Frictional force is exerted on the body by the surface.
Exercise 1:

Average daily human diet has an energy content of 2000 kcal. Convert this 2000 kcal per day into watts.
**Power**: rate at which energy is converted to work

\[
\text{Power} = \frac{\text{energy}}{\text{time}}
\]

**Units**: Joules per second, \( J/s \), or watts (W)

Familiar units of power: kilo-watt, kW

\( 1\text{hp} = 746 \text{ W} \)

Energy = power \times time = \text{kWh} is what you get charged for...😊
6. USA imports about 12 million barrels of oil per day.
   a) what is this in terms of equivalent power?

   b) suppose we wanted to replace all the imported oil with energy produced by fission from domestic uranium. How many 1000 MW nuclear power plants would we have to build?
14. An energy efficient refrigerator consumes energy at the rate of 280W when it is actually running, but it is so well insulated that it runs only about one-sixth of the time. You pay for that efficiency up front: it costs $950 to buy the refrigerator.

You can buy a conventional refrigerator at $700. However, it consumes 400 W when running, and it runs one-fourth of the time. Calculate the total energy used by each refrigerator over a 10 year lifetime and then compare the total costs—purchase price + energy cost—assuming electricity costs 10 cents per kilowatt-hour.
Efficiency & Power loss in Transmission of Electricity
What is electricity?

Electricity & Magnetism are closely related.

Electricity...is a flow/stream of charges...Current (I)

Resistance to flow of Electricity or current....R=Voltage/Current

Energy...electrical potential energy....Voltage (V)

V=IR  energy transferred is equal to current x resistance

Work is transfer of Energy

Work = force x distance

Power=Energy (Work done)/time

Power loss in electrical transmission ......I^2R
Electric force per unit charge: Electric Field $\frac{N}{\text{coulomb}} = \text{Volt/m}$

$$E = \frac{kQ}{r^2}$$
Watt is a unit of power.....

How is it that kilowatt-hour is a unit of energy?

Watt = Joule/second
Kilowatt = 1000 Joules/second =
Kilowatthour = 1000 Joules/second x 1 hr x 3600s/hr =
= 3600000 Joules or 3.6 x10^6 Joules
**Induction:**

[http://www.generatorguide.net/howgeneratorworks.html](http://www.generatorguide.net/howgeneratorworks.html)

Steam-powered Generator

One example....
A water turbine is a rotary engine that takes energy from moving water.
Transformers...

So...we want to minimize losses...\( P=I^2R \)

Low current transmission
high voltage

But we want to use the energy when it arrives safely.....

Solution... Transformers....

Input \( V/(N_{in}) \) = Output \( V/ (N_o) \)
output \( V = \) input \( V \times (N_o/N_{in}) \)
Transformer: raise Voltage for transmission
And you want to lower voltage for use (safety).

The product of current x voltage is kept essentially constant.

\[
\frac{V_{\text{primary}}}{N_{\text{primary}}} = \frac{V_{\text{secondary}}}{N_{\text{secondary}}}
\]

\[\text{output } V = \text{input } V \times \left( \frac{N_{\text{secondary}}}{N_{\text{primary}}} \right)\]