Chapter 10 – Energy Sources, Work and Power
Content

• Sources of Energy
  – Renewable and Non-renewable Sources

• Types of Energy
  – Hydroelectric and tidal energy
  – Wind energy
  – Geothermal energy
  – Solar energy
  – Biofuel

• Law of Conservation of Energy and its application
  – Mechanical and electrical energy
  – Work and Power
Sources of Energy

• Energy – the ability to do work or the capacity to do work

• The combination of energy & matter make up the universe:
  – Matter is the substance and energy causes the transformation of substances

• Source of energy can either be Renewable or Non-renewable form
Sources of Energy

NON-RENEWABLE
- Nuclear
- Oil
- Natural Gas
- Coal

RENEWABLE
- Biomass
- Solar
- Geothermal
- Water
- Wind
Non-Renewable Energy

• Crude oil, Natural, Coal & Nuclear Energy
• Crude oil, Natural, Coal are also referred to as Fossil Fuels – formed from the fossilized remains of pre-historic plant & animal material
• provide around 66% of the world's electrical power, and 95% of the world's total energy demands
• Crude oil – used to manufacture paraffin, petrol, diesel, jet fuel & plastics
• Fossil fuels are limited, hence non-renewable
How Fossil Fuel Works

• Coal is crushed to a fine dust and burnt
• Oil and gas can be burnt directly.
• Burn fuel > heat water to make steam > steam turns turbines > turbines turns generators > electrical power sent around the country
• Coal provides around 28% of our energy, and crude oil provides 40%.
• Crude oil (called "petroleum") is easier to get out of the ground than coal, as it can flow along pipes. This also makes it cheaper to transport.
Advantages to Using Fossil Fuels

• Very large amounts of electricity can be generated in one place using coal, fairly cheaply.

• Transporting oil and gas to the power stations is easy.

• Gas-fired power stations are very efficient.

• A fossil-fuelled power station can be built almost anywhere
Disadvantages of Using Fossil Fuels

• the main drawback of fossil fuels is pollution.
• Burning any fossil fuel produces carbon dioxide, which contributes to the "greenhouse effect", warming the Earth.
• Burning coal produces sulphur dioxide, a gas that contributes to acid rain.
• Importing of crude oil leads to oil spills in the oceans.
• Mining coal can be difficult and dangerous. Strip mining destroys large areas of the landscape.
Non-Renewable Energy

• Nuclear Energy – stored chemical energy in the nucleus of atoms is released through a process called fission

• Fission - splitting of nucleus into smaller parts, of mostly radioactive elements to produce energy e.g. uranium

• Nuclear power produces around 11% of the world's energy needs, and produces huge amounts of energy from small amounts of fuel, without the pollution that you'd get from burning fossil fuels.
How Nuclear Power Works

• The reactor uses Uranium rods as fuel, and the heat is generated by nuclear fission. Neutrons smash into the nucleus of the uranium atoms, which split roughly in half and release energy in the form of heat.

• Nuclear fission makes heat > heated water makes steam > steam turns turbines > turbines turn generators > electrical power is sent around the country
Advantages to Using Nuclear Power

• Nuclear power costs about the same as coal, so it's not expensive to make.
• Does not produce smoke or carbon dioxide, so it does not contribute to the greenhouse effect.
• Produces huge amounts of energy from small amounts of fuel.
• Produces small amounts of waste.
• Nuclear power is reliable.
Disadvantages of Nuclear Power

• Although not much waste is produced, it is very, very dangerous.
• Nuclear radiation emitted is harmful to humans
• Nuclear waste products remain for a long time in the environment
Renewable Energy

• Defined as energy that is produced from resources which are continually replenished on a human timescale

• Currently, this energy forms a very small percentage of the energy sources we use in our everyday activities

• Examples include:
  – Hydroelectric energy
  – Tidal
  – Wind energy
  – Geothermal
  – Solar energy
  – Biofuels
Hydroelectric Energy

- Involves building a dam wall in an area to allow a river to fill up behind the wall.
- Water flows through control gate turns turbines.
- Generators built within the dam wall generate electricity from the turbines.
- Electricity from the power plant is carried to rest of the country via power lines.
Hydroelectric Energy

- Hydroelectric Energy (use water to turn turbines) produce electric the same way as coal-powered power plants (use steam to turn turbines)
- Hydroelectric is a clean source of Energy
- However, it’s expensive to build dams and building of a dam may lead to flooding and environmental damage
Tidal Energy

• Form of hydro power which uses the tidal movements of the ocean as water flows back and forth

• Two ways to generate electricity with tides involve use of:
  1) Kinetic Energy that powers turbines as water moves between full and ebb tide
  2) Potential Energy in which barrages are used to exploit the difference between full and low tide
Tidal Energy

This tidal electricity generation works as the tide comes in and again when it goes out. The turbines are driven by the power of the sea in both directions.
Wind Energy

• Source of energy which has been used for a long time e.g. use of windmills in the middle ages

• From of solar energy

• Wind caused as a result of the sun heating the earth’s surface unevenly

• Warm patches of air rises, causing the cooler dense air to replace the warmer lighter air
Wind Energy

use the kinetic energy in the wind by building tall towers with propellers (wind turbines) attached at the top and generators to convert energy into electrical energy.
Advantages to Wind power

• Wind is free, wind farms need no fuel.
• Produces no waste or greenhouse gases.
• The land beneath can usually still be used for farming.
• Wind farms can be tourist attractions.
• A good method of supplying energy to remote areas.
Disadvantages of Wind Power

• The wind is not always predictable - some days have no wind.
• Suitable areas for wind farms are often near the coast, where land is limited and expensive.
• Coverage of the landscape with wind turbines is unsightly and spoils landscape
• Can kill birds - migrating flocks tend to like strong winds.
• Noisy - wind generator makes a constant, low "swooshing" noise
Geothermal Energy

• Geothermal means heat from the earth

• Originates from:
  – heat trapped within the earth’s core
  – Decay of natural occurring substances and;
  – Movement of continental plates as they slide against each other

• Volcanoes, hot springs and steam vents represent easy accessible points to the energy

• Often, geothermal energy accessed through drilling into the earth’s crust
Geothermal Energy

• Steam produced from underground rocks is used to drive turbines, which drive electric generators to produce electricity

• Geothermal energy can also be used as a heating source
  – Hot water brought to the surface is sent through insulated pipes and into radiator panels
Solar Energy

• Use of solar panels or photovoltaic cells to convert light (photons) from the sun into electricity
• Solar cells in panels made from elements that can produce electric current when light is absorbed
  • e.g. silicon
• Solar panels used in a variety of different applications, including:
  – Telecommunications
  – Solar geysers
  – Solar furnaces (huge array of mirrors focusing light to produce high temperatures)
Biofuel

• Include solid biomass, liquid biofuel and various bio-gases
• Biofuel obtained from plant and animal matter
• Plant and animal matter is used to produce fuels such as bioethanol, methanol, biodiesel and natural gas.
• Plant and animal matter include:
  – Sugar canes, animal manure, animal fat, vegetable oil, woodchips, seaweed, corn stalks
Advantages to Biomass

- use of organic waste materials to produce energy
- The fuel tends to be cheap to produce compared to fossil fuels
- Less demand on the Earth's resources.
Disadvantages to Using Biomass

• Collecting of the organic waste in sufficient quantities can be difficult.
• Burning and fermentation of biomass produces greenhouse gases.
• Biofuel produced from plant matter may cause the depletion of soil nutrients
Law of Conservation of Energy

• Energy cannot be created or destroyed; it may be transformed from one form into another, but the total amount of energy never changes.

• Total energy = Potential energy + Kinetic energy

• Potential E - energy of position or energy in storage.

• Kinetic Energy - energy of motion, the form capable of doing work
How is all energy divided?

All Energy

Potential Energy

- Gravitation Potential Energy
- Elastic Potential Energy

Kinetic Energy

- Chemical Potential Energy
Gravitational Potential Energy

- the energy an object has because of its position relative to the earth.

\[ PE = mgh \]

where,

\( m \) = mass of object

\( g \) = gravitational acceleration (9.8 m.s\(^{-2}\))

\( h \) = height of object
Kinetic Energy

• Energy a object possess due to its motion

\[ KE = \frac{1}{2} mv^2 \]

where,

\( m = \) mass of object
\( v = \) velocity (m.s\(^{-1}\))
Energy  ➔ Work

• Energy is the capacity to do work and Work is the process of transferring the energy through motion

• Work – done when a force is exerted on an object through a distance in the direction of the force.

  \[ \text{Work} = \text{Force} \times \text{distance} \]
  
  = N\cdot m
  = Joules

• Energy and Work have the same units
  KWH, Joules, Calorie, K-Calories
Work Example

• You carry a **20 kg suitcase** upstairs, a **distance of 4m**. How much work did you do?

\[
W = F \times d
\]

a) \( F = ma \)

\[
= (20 \text{ kg}) (9.8 \text{ m/s}^2) = +200 \text{ N}
\]

b) \( W = F \times d \)

\[
= (+200 \text{ N}) (4\text{ m})
\]

\[
= + 800 \text{ J}
\]
Calculate Work

- During the ascent phase of a rep of the bench press, the lifter exerts an *average* vertical force of 1000 N against a barbell while the barbell moves 0.8 m upward.

- How much work did the lifter do to the barbell?
Calculate Work

Table of Variables:

Force = +1000 N
Distance  = +0.8 m

Work = Force x distance
      = (+1000N) x (+0.8m)
      = 800 J
Work Calculation

• A cart at the top of a 0.3 Km hill has a mass of 420 g. What is the cart’s gravitational potential energy? Assuming that energy is conserved and there is no friction, calculate the cart’s speed at the bottom of the hill.
POWER

• Power – Rate at which work is done or the rate of transfer of energy

• Therefore,

\[
\text{Power} = \frac{\text{Work done}}{\text{time taken}} \\
= \frac{\text{(force x distance)}}{\text{time}} \\
= \text{J.s}^{-1} \\
= \text{watts}
\]

or \( \text{Power} = \text{Force} \times \text{Velocity} \)

\( \text{since velocity} = \frac{\text{Distance}}{\text{time}} \)

• Watt is defined as the expenditure of 1 joule of energy in 1 second.
## Important formulas and units

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Definition</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force</td>
<td>mass x accel.</td>
<td>newtons</td>
</tr>
<tr>
<td>Work</td>
<td>force x distance</td>
<td>joules</td>
</tr>
<tr>
<td>Energy</td>
<td>power x time</td>
<td>joules</td>
</tr>
<tr>
<td>Power</td>
<td>work / time</td>
<td>watts</td>
</tr>
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</table>
Ex. Problem on Power:

• Your CD system, uses 250 watts of electrical power.
• You play it for 3 hrs. How much energy used? About how much would it cost? If one kWh is 8 cents.
• Energy (J) = power (watts) x time (sec)
  = (250w) (3hr)
  = 750 Whr
  = 0.75 kWh

• The cost = 8 cents/ kWh x 0.75 kWh
  = 6 cents
Electrical Energy & Power

• The potential difference between two points as the work done when one coulomb of electricity moves from one point to another
• If p.d applied is volts (v) and quantity of electricity which passes is Q (coulomb), then

work done (W) = VQ

or W = V x It

where t = time, V = volts and I = current
Electrical Energy & Power

• work done (W) = V x It

• Using Ohm’s Law

\[ V = IR \text{ or } I = V/R, \]  

the expression for the work done or electrical energy expanded can be written in the following three forms:

\[ W = IVt \text{ or } W = V^2t / R \text{ or } W = I^2Rt \]

where R = resistance
Problem 1

A 2500 gram Ball is thrown into the air with an initial velocity of 30 cm/sec.

a. How much kinetic energy does the ball have?

b. How much potential energy does the ball have when it reaches the top of its ascent?

c. How high into the air did the ball travel?
This graph shows a ball rolling from A to G. The ball starts at point A and rolls to point G.

a) At what letter does the ball have the greatest kinetic energy? __________

b) Which letter shows the ball when it has the maximum potential energy? __________

c) Which letter shows the ball when it has the least potential energy? __________

d) Why is point G slightly lower than point A? In other words, why couldn’t the ball go back to the same height at which it started?
Problem 3

A heater working with 30V potential difference has power 180 watt.

a. Find the current passing through the radiator.
b. Find the resistance of the radiator.