Here's a snapshot of the key formulas and concepts from the chapter to help with your revision.

Key Concepts 📝

- [cite_start]**Energy Stores**: Energy can be stored in several ways, including **kinetic**, **gravitational potential**, **chemical**, **elastic (strain)**, **nuclear**, **electrostatic**, and **internal (thermal)**. [cite: 21]
- [cite_start]**Energy Transfers**: Energy is transferred from one store to another through four main processes: **mechanical working** (forces), **electrical working** (currents), **waves** (like light and sound), and **heating**. [cite: 65, 66, 67, 68]
- [cite_start]**Conservation of Energy**: This fundamental principle states that **energy cannot be created or destroyed**; it is only transferred from one store to another. [cite: 84, 603] [cite_start]In any transfer, some energy is usually "wasted" by being transferred to the surroundings as non-useful thermal energy. [cite: 90, 93]
- [cite_start]**Work**: In physics, work is done when a force causes movement. [cite: 304] [cite_start]The amount of work done is a measure of the energy transferred. [cite: 78, 297]
- [cite_start]**Power**: Power is the **rate at which work is done** or the **rate at which energy is transferred**. [cite: 561, 562] A more powerful device transfers the same amount of energy in less time.
- **Energy Resources**:
  - [cite_start]**Non-renewable**: These sources can be used up and cannot be replaced, such as fossil fuels (coal, oil, gas) and nuclear fuels. [cite: 348] [cite_start]They have a high energy density. [cite: 349]
  - [cite_start]**Renewable**: These sources cannot be exhausted and are generally less polluting. [cite: 366] [cite_start]Examples include solar, wind, hydroelectric, and geothermal energy. [cite: 598]
  - [cite_start]**The Sun**: The sun is the original source for most of our energy resources, except for geothermal, nuclear, and tidal energy. [cite: 596]

Key Formulas ➗

- **Kinetic Energy (E_k)**
  [cite_start]$E_k = \frac{1}{2}mv^2$ [cite: 130]
  - E_k = kinetic energy (in Joules, J)
  - **m** = mass (in kg)
  - **v** = speed (in m/s)

- **Gravitational Potential Energy (ΔE_p)**
  [cite_start]$\Delta E_p = mg\Delta h$ [cite: 149]
  - ΔE_p = change in potential energy (in J)
  - **m** = mass (in kg)
  - **g** = gravitational field strength (in N/kg or m/s^2)
  - Δh = change in vertical height (in m)
- **Work Done (W)**
  [cite_start]$W = Fd$ [cite: 309]
  - **W** = work done (in J)
  - **F** = force (in Newtons, N)
  - **d** = distance moved in the direction of the force (in m)
- **Power (P)**
  [cite_start]$P = \frac{W}{t}$ or $P = \frac{\Delta E}{t}$ [cite: 563, 567]
  - **P** = power (in Watts, W)
  - **W** or ΔE = work done or energy transferred (in J)
  - **t** = time taken (in s)
- **Efficiency**
  [cite_start]$efficiency = \frac{\text{useful energy/power output}}{\text{total energy/power input}} \times 100\%$ [cite: 514, 525]
  Here is a more detailed summary of the chapter on Energy, Work, and Power, with a special focus on the energy resources section, to aid in your revision.

Page 1: Fundamental Concepts of Energy, Work, and Power

What is Energy?

[cite_start]Energy is a fundamental concept that links many phenomena in science[cite: 731]. [cite_start]It is required for devices to work and for processes to occur[cite: 734]. [cite_start]Energy is not a substance but a quantity that is always conserved[cite: 807].

Energy Stores

[cite_start]Energy can be stored in several different ways[cite: 742]. The main stores are:

- [cite_start]**Kinetic Energy (E_k)**: The energy of any moving object[cite: 758]. [cite_start]The faster an object moves, the more kinetic energy it has[cite: 758].

- [cite_start]**Gravitational Potential Energy (E_p)**: The energy an object has due to its position in a gravitational field, such as an object held above the ground[cite: 751, 752].
- [cite_start]**Chemical Energy**: Energy stored in substances like food, fuels (oil, gas, coal), and batteries[cite: 746, 749]. [cite_start]This energy is released through chemical reactions[cite: 747].
- [cite_start]**Elastic (Strain) Energy**: Energy stored when an object is stretched or compressed, like a spring or a drawn bowstring[cite: 755].
- [cite_start]**Nuclear Energy**: Energy stored in the nucleus of an atom, released during nuclear reactions like fission and fusion[cite: 764, 765].
- [cite_start]**Electrostatic Energy**: Energy stored by charged objects[cite: 761].
- [cite_start]**Internal (Thermal) Energy**: The energy associated with the temperature of an object[cite: 767].

Energy Transfers

[cite_start]Energy is useful because it can be transferred from one store to another[cite: 733]. The main ways energy is transferred are:

- [cite_start]**Mechanical Working**: When a force acts and causes movement[cite: 790].
- [cite_start]**Electrical Working**: When an electric current flows[cite: 790].
- [cite_start]**Waves**: Energy transferred by electromagnetic waves (like light) or sound waves[cite: 790].
- [cite_start]**Heating**: Energy transferred via conduction, convection, or radiation[cite: 791].

The Principle of Conservation of Energy

[cite_start]This is a critical law in physics: **Energy cannot be created or destroyed; it is always conserved**[cite: 807].
[cite_start]When energy is transferred, the total amount remains the same, but it often becomes less useful[cite: 736]. [cite_start]For instance, when a brick falls, its potential energy is transferred to kinetic energy[cite: 814]. [cite_start]When it hits the ground, this energy is transferred to the surroundings as thermal energy (heating) and sound[cite: 815]. [cite_start]This dissipated thermal energy is considered "wasted" because it is spread out and difficult to use again[cite: 813].
[cite_start]This is why we constantly need new sources of useful energy[cite: 817].

Work

[cite_start]In physics, **work** is done when a force causes an object to move a certain distance[cite: 1018, 1027]. [cite_start]The work done is a measure of the energy transferred[cite: 1025].

- [cite_start]**Formula**: $W = Fd$ [cite: 1032]
  - W = Work done (in Joules, J)
  - F = Force (in Newtons, N)
  - d = distance moved in the direction of the force (in metres, m)

Power

[cite_start]Power is the **rate at which work is done** or the **rate at which energy is transferred**[cite: 1284, 1285]. [cite_start]A more powerful device does the same amount of work in less time[cite: 1283].

- [cite_start]**Formula**: $P = W/t$ or $P = \Delta E/t$ [cite: 1286, 1290]
  - P = Power (in Watts, W)
  - W or ΔE = Work done or Energy transferred (in J)
  - t = time taken (in seconds, s)

Page 2: Energy Resources – Non-Renewable Sources

[cite_start]Energy resources are the raw materials we use for energy production[cite: 1061]. They are divided into two main categories: non-renewable and renewable.

Non-Renewable Energy Sources

[cite_start]These are sources that **cannot be replaced once they are used up**[cite: 1071].

Advantages of Non-Renewable Fuels

- [cite_start]**High Energy Density**: They are concentrated sources of energy, meaning a small amount of fuel can release a large amount of energy[cite: 1072].
- [cite_start]**Availability**: They are readily available and can be used to meet sudden or seasonal increases in energy demand[cite: 1073].

Types of Non-Renewable Sources

1. Fossil Fuels (Coal, Oil, Natural Gas)

- [cite_start]**Origin**: Formed from the remains of plants and animals that lived millions of years ago, storing energy that originally came from the Sun[cite: 1074]. [cite_start]They are our main energy

source at present[cite: 1075].

- **Disadvantages & Environmental Impact**:
  - [cite_start]**Pollution**: Burning fossil fuels pollutes the atmosphere[cite: 1077].
  - [cite_start]**Carbon Dioxide (CO_2)**: This greenhouse gas aggravates the greenhouse effect and contributes to global warming[cite: 1078]. [cite_start]Natural gas produces less CO_2 than oil or coal for the same energy output[cite: 1079].
  - [cite_start]**Sulfur Dioxide (SO_2)**: Produced when coal and oil are burned, this gas causes **acid rain**[cite: 1081]. [cite_start]Removing sulfur is a costly process[cite: 1082].
  - [cite_start]**Finite Supply**: Estimates suggest oil and gas will run low in this century, though coal may last longer[cite: 1076].

2. Nuclear Fuels (Uranium)

- [cite_start]**Process**: Energy is released from the fission (splitting) of uranium atoms in a nuclear reactor, which can be used to generate electricity[cite: 1084].
- **Advantages**:
  - [cite_start]Does not pollute the atmosphere with carbon dioxide or sulfur dioxide[cite: 1085].
- **Disadvantages & Environmental Impact**:
  - [cite_start]**Radioactive Waste**: The process generates dangerous radioactive waste materials with very long half-lives, which must be stored safely for thousands of years[cite: 1085, 1086].
  - [cite_start]**Risk of Accidents**: While normally safe, an accident can cause a leak of dangerous radioactive material over a large area, as seen in the Fukushima disaster[cite: 1087, 1212].
  - [cite_start]**High Costs**: Building and decommissioning nuclear power stations is more expensive than for gas- or coal-fired stations[cite: 1207].

Power Generation from Non-Renewable Sources

- [cite_start]**Thermal Power Stations**: Both fossil fuels and nuclear fuels are used in thermal power stations[cite: 1160].
  - [cite_start]The fuel is used to provide thermal energy that heats water, turning it into **steam**[cite: 1160, 1161].
  - [cite_start]This high-pressure steam drives **turbines** (large wheels with blades)[cite: 1161, 1165].
  - [cite_start]The rotating turbines then drive **generators** that produce electricity[cite: 1161].
- [cite_start]**Low Efficiency**: Thermal power stations are only about **30% efficient**[cite: 1184]. [cite_start]A large amount of energy is wasted, primarily as thermal energy lost in cooling towers

used to condense the steam back into water[cite: 1185].

- [cite_start]**Gas-Fired Power Stations**: Newer gas-fired stations can be more efficient (over 50%) by using a combined cycle, where hot exhaust gases from a gas turbine are used to produce more steam, generating extra electricity[cite: 1167, 1168, 1169]. [cite_start]They also produce less pollution than coal[cite: 1170].

Page 3: Energy Resources – Renewable Sources & Efficiency

Renewable Energy Sources

[cite_start]These are sources that **cannot be exhausted** and are generally **non-polluting**[cite: 1089]. [cite_start]The Sun is the main source for most of these, with the exceptions being geothermal, nuclear, and tidal energy[cite: 1148].

Types of Renewable Sources

- [cite_start]**Solar Energy**: Energy from the Sun comes as visible light and infrared radiation[cite: 1091].
  - [cite_start]**Advantages**: Free and non-polluting[cite: 1089].
  - [cite_start]**Disadvantages**: Has a **low energy density**, requiring large collection devices, and its **availability varies** with weather and time of day[cite: 1092].
  - [cite_start]**Uses**: Heating water in solar panels, high-temperature heating in solar furnaces, and generating electricity directly in **solar cells**[cite: 1094, 1095, 1097].
- [cite_start]**Wind Energy**: Caused by the Sun's energy driving weather systems[cite: 1110]. [cite_start]**Wind turbines** are used to drive electrical generators[cite: 1111].
  - [cite_start]**Disadvantages**: Can be noisy and considered unsightly[cite: 1113]. [cite_start]The best sites for wind farms are often in areas of natural beauty[cite: 1113]. [cite_start]Their output is unreliable as it depends on wind strength[cite: 1219].
- [cite_start]**Hydroelectric & Tidal Energy**: Uses the flow of water from a higher level to a lower level to drive a water turbine connected to a generator[cite: 1120].
  - [cite_start]**Advantages**: A reliable energy source with a very short start-up time, making it ideal for meeting peak electricity demand[cite: 1126, 1217]. [cite_start]Hydroelectric schemes have very high efficiency (85-90%)[cite: 1173].
  - [cite_start]**Disadvantages**: Building large dams or tidal barrages can destroy wildlife habitats and require flooding large areas of land[cite: 1122, 1127].

- [cite_start]**Geothermal Energy**: Cold water is pumped down to hot rocks deep in the Earth, which turns it into steam that can be used to drive a turbine[cite: 1133, 1134]. [cite_start]The rocks are heated by the decay of radioactive elements[cite: 1135].
    - [cite_start]**Disadvantage**: Can only be built in specific geographic locations where rocks are hot enough close to the surface[cite: 1137].
- [cite_start]**Biofuels**: Fuels derived from organic matter (biomass) like crops, wood, or animal waste[cite: 1139].
    - [cite_start]**Advantages**: Liquid biofuels are lead- and sulfur-free, reducing pollution[cite: 1141]. [cite_start]Biogas can be produced cheaply on a small scale from waste[cite: 1144].
    - [cite_start]**Disadvantages**: Have a lower energy content than petrol[cite: 1141]. [cite_start]Biogas is unstable and can be explosive[cite: 1145]. [cite_start]Not economically viable for large-scale production[cite: 1144].

Choosing Energy Sources: Key Factors

When deciding which energy sources to use, several factors must be considered:

- [cite_start]**Costs**: This includes capital costs for building the station, fuel costs, and decommissioning costs[cite: 1206, 1207]. [cite_start]While renewables have no fuel costs, their capital costs can be high because the energy is dilute[cite: 1206].
- [cite_start]**Reliability**: Non-renewable sources and hydroelectric power are very reliable[cite: 1216, 1217]. [cite_start]Wind and solar are less reliable because they depend on the weather[cite: 1219].
- [cite_start]**Start-up Time**: Natural gas and hydroelectric stations can be started up very quickly[cite: 1215, 1217]. [cite_start]Nuclear power stations take the longest[cite: 1216].
- [cite_start]**Environmental Impact**: This includes issues like air pollution from fossil fuels, radioactive waste from nuclear power, and habitat destruction from hydroelectric dams[cite: 1077, 1085, 1122].

Efficiency of Energy Transfers

[cite_start]The efficiency of a device measures how good it is at transferring energy into useful stores[cite: 1235, 1246]. No device is 100% efficient; some energy is always lost, usually as thermal energy.

- **Formula**:
  [cite_start]$$efficiency = \frac{\text{useful energy (or power) output}}{\text{total energy (or power) input}} \times 100\%$$ [cite: 1237, 1248]