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Design and Manufacture a Rotational Wheel to Use Gravity Power

A project submitted in partial fulfillment of the requirements for the degree of bachelor mechanical engineering

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بسم الله الرحمن الرحيم

يَا أَيُّهَا الَّذِينَ آمَنُوا
اتَّقُوا اللَّهَ وَابْتَغُوا إِلَيْهِ الْوَسِيلَةَ
وَجَاهِدُوا فِي سَبِيلِهِ
لَعَلَّكُمْ تُفْلِحُونَ

صدق الله العظيم

سورة المائدة
آية ٣٥

Abstract

Renewable and cheap energy is one of the important subjects in recent years due to environmental changes and the economic challenges. Gravity is a huge source of energy having a wide physical effects; however, this energy had been used to produce energy. This study explores the conceptualization, design, and manufacturing of a rotational wheel driven by gravity power. The project aims to develop a mechanical system that leverages gravitational force to achieve continuous rotational motion, providing an alternative, sustainable energy source. The design process involves detailed theoretical analysis, including calculations of torque, energy efficiency, and material selection, to optimize the wheel's performance. Available manufacturing techniques were employed to ensure precision and durability. Prototypes were tested under varying conditions to evaluate efficiency and performance. The findings demonstrate the potential of gravity-powered rotational systems for applications in energy generation and mechanical devices, presenting a promising step toward eco-friendly and renewable energy solutions.

Dedication

الحمد لله والصلاة والسلام على اشرف المخلوقات محمد واهل بيته اما بعد:

الحمد لله الذي وفقنا لتثمين هذه الخطوة في مسيرتنا الدراسية بمذكرتنا هذه ثمره جهد والنجاح بفضله تعالى مهداه الى اهالي غزه الاحرار ومقاومتها الباسلة والى الشهداء ابو مهدي المهندس وقاسم سليماني والسيد القائد حسن نصرالله تغمدهم الله برحمته والى الوالدين الكريمين حفظ حفظهم الله والى شهدائنا الابرار ولكل من كان لهم اثر على حياتي والى كل من احبهم ونسيهم قلبي

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شكر وتقدير

قال تعالى (وَلَقَدْ آتَيْنَا لُقْمَانَ الْحِكْمَةَ أَنِ اشْكُرْ لِلَّهِ ۚ وَمَنْ يَشْكُرْ فَإِنَّمَا يَشْكُرُ لِنَفْسِهِ ۖ وَمَنْ كَفَرَ فَإِنَّ اللَّهَ غَنِيٌّ حَمِيدٌ) (لقمان:١٢)

وقال رسوله الكريم (ص): "من لم يشكر المخلوق، لم يشكر الخالق"

نحمد الله تعالى حمدا دائما لا ينقطع ابدا على ما اكرمني به من اتمام هذا المشروع ثم نتوجه بجزيل الشكر وعظيم الامتنان الى الدكتور الفاضل أ.م.د.جاسم حسن علك حفظه الله وامد في عمره

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1.1. Introduction

Energy is at the heart of the climate challenge and key to the solution for saving the earth from deterioration. A large chunk of the greenhouse gases that blanket the Earth and trap the sun's heat and the heat generated through the energy production, by burning fossil fuels to generate electricity.

Fossil fuels, such as coal, oil and gas, are by far the largest contributor to global climate change, accounting for over 75 percent of global greenhouse gases emissions and nearly 90 percent of all carbon dioxide emissions.

The science is clear: to avoid the worst impacts of climate change, emissions need to be reduced by almost half by 2030 and reach net-zero by 2050. To achieve this, we need to end our reliance on fossil fuels and invest in alternative sources of energy that are clean, accessible, affordable, sustainable, and reliable.

Renewable energy sources are available in abundance all around us, provided by the sun, wind, water, waste, and heat from the Earth. These sources are replenished by nature and emit little to no greenhouse gases or pollutants into the air.

Fossil fuels still account for more than 80 percent of global energy production, but cleaner sources of energy are gaining ground. About 29 percent of electricity currently comes from renewable sources.

Here are five reasons why accelerating the transition to clean energy is the pathway to a healthy, livable planet today and for generations to come.

Figure 1. Two renewable sources of energy (solar, and wind)

The human trying to use the available sources of clean and renewable energy however, there are another sources do not bring the attention such as the power of gravity which can be used in special designs to convert this energy to other kinds.
In this study, we try to convert the gravitational energy into mechanical energy to rotate a special design of wheel to have a continuous rotating motion which can be modified later to convert this rotational energy into electricity.

1.2 Types of renewable energy:

There were many types of renewable energy :

- Wind energy
- Solar energy
- Hydro energy
- Geothermal energy
- Semiconductor energy

1.2.1 Wind energy

Definition Wind energy is a form of renewable energy source, in which turbines convert the kinetic energy of the wind into mechanical or electrical energy, and this energy is used to provide the necessary power needed by many different fields, such as industry, agriculture, and others.
Turbines convert wind energy into electrical energy by using the aerodynamic force resulting from the rotating blades, which work with the same idea as the wings of an airplane or propeller, when the wind flows and reaches the vane, the air pressure on one side of this vane decreases, and this difference in pressure leads to the creation of lifting and pulling forces. The lifting force is stronger than the pulling force, and this leads to the rotation of the vane, which is connected to the generator, either directly by the turbine or indirectly through a shaft and gearbox, and this leads to the operation of the generator that generates electricity.

Figure-2. Wind farm consisting many wind turbines.

1.2.2 Solar energy

Solar power is energy from the sun that is converted into thermal or electrical energy. Solar energy is the cleanest and most abundant renewable energy source available, and the U.S. has some of the richest solar resources in the world. Solar technologies can harness this energy for a variety of uses, including generating electricity, providing light or a comfortable interior environment, and heating water for domestic, commercial, or industrial use.

Solar energy is a very flexible energy technology: it can be built as distributed generation (located at or near the point of use) or as a central-station, utility-scale solar power plant (similar to traditional power plants). Both of these methods can also store the energy they produce for distribution after the sun sets, using cutting-edge solar + storage technologies. Solar exists within a complex and interrelated electricity system in the U.S., working alongside other technologies like wind power to transition the U.S. to a clean energy economy.

All of these applications depend on supportive policy frameworks at the local, state, and federal level to ensure consumers and businesses have fair access to clean energy technologies like solar.

Figure-3 Solar energy blades to achieve electric energy.

1.2.3 Hydroelectricity energy

Hydroelectricity, also known as hydropower, is the most widely used form of renewable energy. It harnesses the energy from flowing water to generate electricity. The concept is simple: water flows through turbines, which spin and generate electricity. The energy is then transmitted via power lines for use in homes, businesses, and industries.

The basic process involves converting the potential energy of water at a higher elevation into kinetic energy and then into electrical energy. Here's a breakdown of how this happens:

Water Source: A large body of water, typically a river or a reservoir, is dammed to create a reservoir. The height of the water behind the dam (called "head") determines the potential energy that can be converted into electricity.

Dam and Penstock: Water from the reservoir is released through a penstock (a large pipe) that directs the flow of water towards the turbines. The higher the water level, the greater the potential energy, which increases the efficiency of the power generation.

Turbine: The fast-moving water spins the blades of a turbine. This mechanical motion is the kinetic energy of water being converted into mechanical energy.

Generator: The turbine is connected to a generator. As the turbine spins, it rotates a shaft connected to the generator, which uses electromagnetic induction to generate electrical energy.

Transmission: The electricity produced is sent through transformers, which increase the voltage, allowing the electricity to travel over long distances through power lines with minimal loss of energy.

Control Mechanisms: Hydroelectric plants often include control gates that can regulate the flow of water, ensuring optimal energy generation and maintaining reservoir levels.

1.2.3.1 Types of Hydroelectric Power Plants

Impoundment (Reservoir): This is the most common type. It involves creating a large reservoir behind a dam. Water is released in a controlled way to generate electricity. Examples include the Three Gorges Dam in China and Hoover Dam in the United States.

Run-of-River: This type of hydroelectric power plant does not require a large reservoir. Instead, it uses the natural flow of a river, diverting some of the water through a canal or penstock to spin the turbines. It is less disruptive to local ecosystems compared to impoundment systems.

Pumped Storage: This is a type of hydroelectric plant used for energy storage. It involves two reservoirs at different elevations. During periods of low electricity demand, water is pumped from the lower reservoir to the upper reservoir. During high demand, the stored water is released to generate electricity. This type of system helps balance energy supply and demand.

Tidal and Wave Power: These are more specialized forms of hydroelectric power, where the energy of ocean tides or waves is harnessed to generate electricity. These systems are still under development but show promise for future use.

1.2.3.2 Advantages of Hydroelectricity

Renewable Energy Source: As long as the water cycle continues, hydroelectric plants can generate electricity indefinitely. Water is naturally replenished through rainfall, snowmelt, and other processes.

Low Emissions: Hydroelectric plants do not burn fossil fuels, making them one of the cleanest energy sources. The operational greenhouse gas emissions are minimal compared to coal, natural gas, or oil plants.

Reliable and Stable: Hydroelectric plants have a long lifespan and can operate continuously, providing a stable supply of electricity, especially in areas with consistent rainfall and high river flows.

Energy Storage: Pumped storage systems can store energy, making hydroelectricity a valuable tool for grid stability, especially when used in conjunction with intermittent renewable energy sources like solar or wind.

Flood Control and Water Supply: Dams and reservoirs provide flood control, water for irrigation, and drinking water, offering additional benefits to local communities.

Economic Growth: Hydroelectric projects can stimulate local economies through job creation and infrastructure development. They can also reduce the cost of electricity in the region.

1.2.3.3 Disadvantages of Hydroelectricity

Environmental Impact: Dams can disrupt local ecosystems. They may impact water quality, fish migration, and wildlife habitats. Fish ladders and other technologies are used to mitigate this, but they are not always fully effective.

Displacement of Communities: Large hydroelectric projects often require the displacement of local communities. The creation of reservoirs can submerge villages, farmland, and forests, causing social and economic challenges.

High Initial Costs: Building hydroelectric plants requires significant capital investment in dams, turbines, and infrastructure. While operational costs are low, the construction phase can take years and can be expensive.

Droughts and Climate Change: Hydroelectric plants rely on water availability. In regions where droughts are common or where the effects of climate change alter precipitation patterns, power generation may decrease. For example, a dry year could lead to lower water levels in reservoirs, limiting energy production.

Safety Risks: Dams, particularly older ones, pose safety risks. If a dam were to fail (e.g., due to structural issues or an earthquake), it could cause catastrophic flooding downstream.

The global capacity of Hydroelectricity accounts for about 16% of the world's electricity production and over 60% of all renewable electricity generation. China, Brazil, Canada, and the United States are some of the largest producers of hydroelectric power.

The growth in developing nations are investing in hydroelectric power to meet growing energy needs. For example, Africa is home to several major hydropower projects, such as the Grand Ethiopian Renaissance Dam, which is expected to significantly boost Ethiopia's electricity supply.

Technological Innovations: Technological advancements in turbine design, materials, and energy storage systems are improving the efficiency and environmental footprint of hydroelectric power. There are also efforts to develop small-scale, modular hydro systems that can be deployed in smaller rivers or streams, reducing environmental impact.

Hydroelectricity remains a cornerstone of the global renewable energy landscape due to its reliability, low emissions, and capacity to generate large amounts of power. While it presents challenges, such as environmental impacts and high initial costs, ongoing technological advancements and a focus on sustainability are helping to mitigate many of these issues. As the world shifts towards cleaner energy, hydroelectricity will continue to play a key role in the global energy mix.

1.2.4 Geothermal energy

Geothermal energy is heat that is generated within Earth. (*Geo* means "earth," and *thermal* means "heat" in Greek.) It is a renewable resource that can be harvested for human use.

About 2,900 kilometers (1,800 miles) below Earth's crust, or surface, is the hottest part of our planet: the core. A small portion of the core's heat comes from the friction and gravitational pull formed when Earth was created more than four billion years ago. However, the vast majority of Earth's heat is constantly generated by the decay of radioactive isotopes, such as potassium-40 and thorium-232. Isotopes are forms of an element that have a different number of neutrons than the most common versions of the element's atom.

Potassium, for instance, has 20 neutrons in its nucleus. Potassium-40, however, has 21 neutrons. As potassium-40 decays, its nucleus changes, emitting enormous amounts of energy (radiation). Potassium-40 most often decays to isotopes of calcium (calcium-40) and argon (argon-40).

Radioactive decay is a continual process in the core. Temperatures there rise to more than 5,000° Celsius (about 9,000° Fahrenheit). Heat from the core is constantly radiating outward and warming rocks, water, gas, and other geological material.

Earth's temperature rises with depth from the surface to the core. This gradual change in temperature is known as the geothermal gradient. In most parts of the world, the geothermal gradient is about 25° C per 1 kilometer of depth (1° F per 77 feet of depth).

If underground rock formations are heated to about 700-1,300° C (1,300-2,400° F), they can become magma. Magma is molten (partly melted) rock permeated by gas and gas bubbles. Magma exists in the mantle and lower crust, and sometimes bubbles to the surface as lava.

Magma heats nearby rocks and underground aquifers. Hot water can be released through geysers, hot springs, steam vents, underwater hydrothermal vents, and mud pots.

These are all sources of geothermal energy. Their heat can be captured and used directly for heat, or their steam can be used to generate electricity. Geothermal energy can be used to heat structures such as buildings, parking lots, and sidewalks.

Most of the Earth's geothermal energy does not bubble out as magma, water, or steam. It remains in the mantle, emanating outward at a slow pace and collecting as pockets of high heat. This dry geothermal heat can be accessed by drilling, and enhanced with injected water to create steam.

Many countries have developed methods of tapping into geothermal energy. Different types of geothermal energy are available in different parts of the world. In Iceland, abundant sources of hot, easily accessible underground water make it possible for most people to rely on geothermal sources as a safe, dependable, and inexpensive source of energy. Other countries, such as the U.S., must drill for geothermal energy at greater cost.

1.2.4.1 Harvesting Geothermal Energy: Heating and Cooling Low-Temperature Geothermal Energy

Almost anywhere in the world, geothermal heat can be accessed and used immediately as a source of heat. This heat energy is called low-temperature geothermal energy. Low-temperature geothermal energy is obtained from pockets of heat about 150° C (302° F). Most pockets of low-temperature geothermal energy are found just a few meters below ground.

Low-temperature geothermal energy can be used for heating greenhouses, homes, fisheries, and industrial processes. Low-temperature energy is most efficient when used for heating, although it can sometimes be used to generate electricity. People have long used this type of geothermal energy for engineering, comfort, healing, and cooking. Archaeological evidence shows that 10,000 years ago, groups of Native Americans gathered around naturally occurring hot springs to recuperate or take refuge from conflict. In the third century BCE, scholars and leaders warmed themselves in a hot spring fed by a stone pool near Lishan, a mountain in central China. One of the most famous hot spring spas is in the appropriately named town of Bath, England. Starting construction in about 60 CE, Roman conquerors built an elaborate system of steam rooms and pools using heat from the region’s shallow pockets of low-temperature geothermal energy.

The hot springs of Chaudes Aigues, France, have provided a source of income and energy for the town since the 1300s. Tourists flock to the town for its elite spas. The low-temperature geothermal energy also supplies heat to homes and businesses.

The United States opened its first geothermal district heating system in 1892 in Boise, Idaho. This system still provides heat to about 450 homes.

1.2.4.2 Co-Produced Geothermal Energy

Co-produced geothermal energy technology relies on other energy sources. This form of geothermal energy uses water that has been heated as a byproduct in oil and gas wells.

In the United States, about 25 billion barrels of hot water are produced every year as a byproduct. In the past, this hot water was simply discarded. Recently, it has been recognized as a potential source of even more energy: Its steam can be used to generate electricity to be used immediately or sold to the grid.

One of the first co-produced geothermal energy projects was initiated at the Rocky Mountain Oilfield Testing Center in the U.S. state of Wyoming.

Newer technology has allowed co-produced geothermal energy facilities to be portable. Although still in experimental stages, mobile power plants hold tremendous potential for isolated or impoverished communities.

1.2.4.3 Geothermal Heat Pumps

Geothermal heat pumps (GHPs) take advantage of Earth's heat, and can be used almost anywhere in the world. GHPs are drilled about three to 90 meters (10 to 300 feet) deep, much shallower than most oil and natural gas wells. GHPs do not require fracturing bedrock to reach their energy source.

A pipe connected to a GHP is arranged in a continuous loop—called a "slinky loop"—that circles underground and above ground, usually throughout a building. The loop can also be contained entirely underground, to heat a parking lot or landscaped area.

In this system, water or other liquids (such as glycerol, similar to a car's antifreeze) move through the pipe. During the cold season, the liquid absorbs underground geothermal heat. It carries the heat upward through the building and gives off warmth through a duct system. These heated pipes can also run through hot water tanks and offset water-heating costs.

During the summer, the GHP system works the opposite way: The liquid in the pipes is warmed from the heat in the building or parking lot, and carries the heat to be cooled underground.

The U.S. Environmental Protection Agency has called geothermal heating the most energy-efficient and environmentally safe heating and cooling system. The largest GHP system was completed in 2012 at Ball State University in Indiana. The system replaced a coal-fired boiler system, and experts estimate the university will save about two million dollars a year in heating costs.

1.2.4.4 Harvesting Geothermal Energy: Electricity

In order to obtain enough energy to generate electricity, geothermal power plants rely on heat that exists a few kilometers below the surface of Earth. In some areas, the heat can naturally exist underground as pockets steam or hot water. However, most areas need to be "enhanced" with injected water to create steam. Dry-Steam Power Plants

Dry-steam power plants take advantage of natural underground sources of steam. The steam is piped directly to a power plant, where it is used to fuel turbines and generate electricity.

Dry steam is the oldest type of power plant to generate electricity using geothermal energy. The first dry-steam power plant was constructed in Larderello, Italy, in 1911. Today, the dry-steam power plants at Larderello continue to supply electricity to more than a million residents of the area.

There are only two known sources of underground steam in the United States: Yellowstone National Park in Wyoming and The Geysers in California. Since Yellowstone is a protected area, The Geysers is the only place where a dry-steam power plant is in use. It is one of the largest geothermal energy complexes in the world, and provides about a fifth of all renewable energy in the U.S. state of California.

Flash-Steam Power Plant

Flash-steam power plants use naturally occurring sources of underground hot water and steam. Water that is hotter than 182° C (360° F) is pumped into a low-pressure area. Some of the water “flashes,” or evaporates rapidly into steam, and is funneled out to power a turbine and generate electricity. Any remaining water can be flashed in a separate tank to extract more energy.

Flash-steam power plants are the most common type of geothermal power plants. The volcanically active island nation of Iceland supplies nearly all its electrical needs through a series of flash-steam geothermal power plants. The steam and excess warm water produced by the flash-steam process heat icy sidewalks and parking lots in the frigid Arctic winter.

The islands of the Philippines also sit over a tectonically active area, the "Ring of Fire" that rims the Pacific Ocean. Government and industry in the Philippines have invested in flash-steam power plants, and today the nation is second only to the United States in its use of geothermal energy. In fact, the largest single geothermal power plant is a flash-steam facility in Malitbog, Philippines.

Binary Cycle Power Plants

Binary cycle power plants use a unique process to conserve water and generate heat. Water is heated underground to about 107°-182° C (225°-360° F). The hot water is contained in a pipe, which cycles above ground. The hot water heats a liquid organic compound that has a lower boiling point than water. The organic liquid creates steam, which flows through a turbine and powers a generator to create electricity. The only emission in this process is steam. The water in the pipe is recycled back to the ground, to be reheated by Earth and provide heat for the organic compound again.

The Beowawe Geothermal Facility in the U.S. state of Nevada uses the binary cycle to generate electricity. The organic compound used at the facility is an industrial refrigerant (tetrafluoroethane, a greenhouse gas). This refrigerant has a much lower boiling point than water, meaning it is converted into gas at low temperatures. The gas fuels the turbines, which are connected to electrical generators.

Enhanced Geothermal Systems

Earth has virtually endless amounts of energy and heat beneath its surface. However, it is not possible to use it as energy unless the underground areas are "hydrothermal." This means the underground areas are not only hot, but also contain liquid and are permeable. Many areas do not have all three of these components. An enhanced geothermal system (EGS) uses drilling, fracturing, and injection to provide fluid and permeability in areas that have hot—but dry—underground rock.

To develop an EGS, an “injection well” is drilled vertically into the ground. Depending on the type of rock, this can be as shallow as one kilometer (0.6 mile) to as deep as 4.5 kilometers (2.8 miles). High-pressure cold water is injected into the drilled space, which forces the rock to create new fractures, expand existing fractures, or dissolve. This creates a reservoir of underground fluid.

Water is pumped through the injection well and absorbs the rocks’ heat as it flows through the reservoir. This hot water, called brine, is then piped back up to Earth’s surface through a “production well.” The heated brine is contained in a pipe. It warms a secondary fluid that has a low boiling point, which evaporates to steam and powers a turbine. The brine cools off, and cycles back down through the injection well to absorb underground heat again. There are no gaseous emissions besides the water vapor from the evaporated liquid.

Pumping water into the ground for EGSs can cause seismic activity, or small earthquakes. In Basel, Switzerland, the injection process caused hundreds of tiny earthquakes that grew to more significant seismic activity even after the water injection was halted. This led to the geothermal project being canceled in 2009.

Geothermal Energy and the Environment

Geothermal energy is a renewable resource. Earth has been emitting heat for about 4.5 billion years, and will continue to emit heat for billions of years into the future because of the ongoing radioactive decay in Earth’s core.

However, most wells that extract the heat will eventually cool, especially if heat is extracted more quickly than it is given time to replenish. Larderello, Italy, site of the world’s first electrical plant supplied by geothermal energy, has seen its steam pressure fall by more than 25 percent since the 1950s.

Re-injecting water can sometimes help a cooling geothermal site last longer. However, this process can cause “micro-earthquakes.” Although most of these are too small to be felt by people or register on a scale of magnitude, sometimes the ground can quake at more threatening levels and cause the geothermal project to shut down, as it did in Basel, Switzerland.

Geothermal systems do not require enormous amounts of freshwater. In binary systems, water is only used as a heating agent, and is not exposed or evaporated. It can be recycled, used for other purposes, or released into the atmosphere as nontoxic steam. However, if the geothermal fluid is not contained and recycled in a pipe, it can absorb harmful substances such as arsenic, boron, and fluoride. These toxic substances can be carried to the surface and released when the water evaporates. In addition, if the fluid leaks to other underground water systems, it can contaminate clean sources of drinking water and aquatic habitats.

Advantages

There are many advantages to using geothermal energy either directly or indirectly:

- Geothermal energy is renewable; it is not a fossil fuel that will be eventually used up. Earth is continuously radiating heat out from its core, and will continue to do so for billions of years.
- Some form of geothermal energy can be accessed and harvested anywhere in the world.
- Using geothermal energy is relatively clean. Most systems only emit water vapor, although some emit very small amounts of sulfur dioxide, nitrous oxides, and particulates.
- Geothermal power plants can last for decades and possibly centuries. If a reservoir is managed properly, the amount of extracted energy can be balanced with the rock's rate of renewing its heat.
- Unlike other renewable energy sources, geothermal systems are "baseload." This means they can work in the summer or winter, and are not dependent on changing factors such as the presence of wind or sun. Geothermal power plants produce electricity or heat 24 hours a day, seven days a week.
- The space it takes to build a geothermal facility is much more compact than other power plants. To produce a GWh (a gigawatt hour, or one million

kilowatts of energy for one hour, an enormous amount of energy), a geothermal plant uses the equivalent of about 1,046 square kilometers (404 square miles) of land. To produce the same GWh, wind energy requires 3,458 square kilometers (1,335 square miles), a solar photovoltaic center requires 8,384 square kilometers (3,237 square miles), and coal plants use about 9,433 square kilometers (3,642 square miles).

- Geothermal energy systems are adaptable to many different conditions.

They can be used to heat, cool, or power individual homes, whole districts, or industrial processes.

1.2.1.1 Disadvantages Harvesting geothermal energy

- The process of injecting high-pressure streams of water into the planet can result in minor seismic activity, or small earthquakes.
- Geothermal plants have been linked to subsidence, or the slow sinking of land. This happens as the underground fractures collapse upon themselves. This can lead to damaged pipelines, roadways, buildings, and natural drainage systems.
- Geothermal plants can release small amounts of greenhouse gases such as hydrogen sulfide and carbon dioxide.
- Water that flows through underground reservoirs can pick up trace amounts of toxic elements such as arsenic, mercury, and selenium. These harmful substances can be leaked to water sources if the geothermal system is not properly insulated.
- Although the process requires almost no fuel to run, the initial cost of installing geothermal technology is expensive. Developing countries may not have the sophisticated infrastructure or start-up costs to invest in a geothermal power plant. Several facilities in the Philippines, for example, were made possible by investments from U.S. industry and government agencies. Today, the plants are Philippine-owned and operated.

Geothermal Energy and People

Geothermal energy exists in different forms all over Earth (by steam vents, lava, geysers, or simply dry heat), and there are different possibilities for extracting and using this heat.

In New Zealand, natural geysers and steam vents heat swimming pools, homes, greenhouses, and prawn farms. New Zealanders also use dry geothermal heat to dry timber and feedstock.

Other countries, such as Iceland, have taken advantage of molten rock and magma resources from volcanic activity to provide heat for homes and buildings. In Iceland, almost 90 percent of the country's people use geothermal heating resources. Iceland also relies on its natural geysers to melt snow, warm fisheries, and heat greenhouses.

The United States generates the most amount of geothermal energy of any other country. Every year, the U.S. generates at least 15 billion kilowatt-hours, or the equivalent of burning about 25 million barrels of oil. Industrial geothermal technologies have been concentrated in the western U.S. In 2012, Nevada had 59 geothermal projects either operational or in development, followed by California with 31 projects, and Oregon with 16 projects.

The cost of geothermal energy technology has gone down in the last decade, and is becoming more economically possible for individuals and companies.

Figure 4 Geothermal energy.

1.2.5 Semi-conductor energy

Semiconductors are materials which have a conductivity between conductors (generally metals) and non-conductors or insulators (such as ceramics). Semiconductors can be compounds, such as gallium arsenide, or pure elements, such as germanium or silicon. Physics explains the theories, properties and mathematical approach related to semiconductors.

Holes and electrons are the types of charge carriers accountable for the flow of current in semiconductors. Holes (valence electrons) are the positively charged electric charge carrier, whereas electrons are the negatively charged particles. Both electrons and holes are equal in magnitude but opposite in polarity.

Mobility of Electrons and Holes

In a semiconductor, the mobility of electrons is higher than that of the holes. It is mainly because of their different band structures and scattering mechanisms.

Electrons travel in the conduction band, whereas holes travel in the valence band. When an electric field is applied, holes cannot move as freely as electrons due to their restricted movement. The elevation of electrons from their inner shells to higher shells results in the creation of holes in semiconductors. Since the holes experience stronger atomic force by the nucleus than electrons, holes have lower mobility.

The mobility of a particle in a semiconductor is more, if

The effective mass of particles is lesser

The time between scattering events is more

For intrinsic silicon at 300 K, the mobility of electrons is 1500 cm2 (V·s)-1, and the mobility of holes is 475 cm^2 $(V·s)^{-1}$.

The bond model of electrons in silicon of valency 4 is shown below. Here, when one of the free electrons (blue dots) leaves the lattice position, it creates a hole (grey dots). This hole thus created takes the opposite charge of the electron and can be imagined as positive charge carriers moving in the lattice.

Types of Semiconductors

1.2.6 Rotational Energy of the Earth

Earth's energy is a vast and diverse source of power that comes from both natural processes and forces present within our planet. While many energy resources have been utilized over the centuries, there are significant forms of Earth-based energy that remain largely untapped or underutilized. One of these includes the rotational energy of Earth itself, which is an immensely powerful and continuously available resource.

The Earth is constantly rotating around its axis, and this rotational motion is a form of kinetic energy. The Earth completes one full rotation every 24 hours, which means it is constantly in motion. The energy from this rotation is massive and can theoretically be harnessed if the right technologies and mechanisms were developed.

Energy Conversion: If we could develop efficient methods to tap into this rotational motion, we could convert a portion of this rotational energy into usable power. The process would involve capturing the motion through mechanisms like turbines or specialized generators that could harness kinetic energy from the Earth's rotation.

Despite the vast potential, Earth's rotational energy remains largely unexploited. Current technologies focus more on solar, wind, and hydroelectric energy sources, with limited attention paid to the Earth's rotational motion. However, the concept of utilizing rotational energy is not entirely new. Some proposed ideas include:

Tidal Energy: The Earth's rotation affects ocean tides, which can be harnessed using tidal energy generators. This is an indirect form of tapping into Earth's rotational energy.

Geothermal Energy: Another indirect benefit from Earth's internal dynamics is geothermal energy, which comes from the heat generated by the Earth's inner layers. Though geothermal is widely used for heating and power generation, it's not a direct exploitation of Earth's rotation itself.

1.3 Characteristics of renewable energies

The following are some characteristics of the renewable energies will be illustrated with few details.

- Renewable energy sources are all around us

About 80 percent of the global population lives in countries that are net-importers of fossil fuels -- that's about 6 billion people who are dependent on fossil fuels from other countries, which makes them vulnerable to geopolitical shocks and crises.

- In contrast, renewable energy sources are available in all countries, and their potential is yet to be fully harnessed. The International Renewable Energy Agency (IRENA) estimates that 90 percent of the world's electricity can and should come from renewable energy by 2050.
- Renewables offer a way out of import dependency, allowing countries to diversify their economies and protect them from the unpredictable price swings of fossil fuels, while driving inclusive economic growth, new jobs, and poverty alleviation.
- Renewable energy is cheap Renewable energy actually is the cheapest power option in most parts of the world today. Prices for renewable energy technologies are dropping rapidly. The cost of electricity from solar power fell by 85 percent

between 2010 and 2020. Costs of onshore and offshore wind energy fell by 56 percent and 48 percent respectively.

Falling prices make renewable energy more attractive all around – including to low- and middle-income countries, where most of the additional demand for new electricity will come from. With falling costs, there is a real opportunity for much of the new power supply over the coming years to be provided by low-carbon sources.

Cheap electricity from renewable sources could provide 65 percent of the world's total electricity supply by 2030. It could decarbonize 90 percent of the power sector by 2050, massively cutting carbon emissions and helping to mitigate climate change.

Although solar and wind power costs are expected to remain higher in 2022 and 2023 then pre-pandemic levels due to general elevated commodity and freight prices, their competitiveness actually improves due to much sharper increases in gas and coal prices, says the International Energy Agency (IEA).

- Renewable energy is healthy: According to the World Health Organization (WHO), about 99 percent of people in the world breathe air that exceeds air quality limits and threatens their health, and more than 13 million deaths around the world each year are due to avoidable environmental causes, including air pollution.

The unhealthy levels of fine particulate matter and nitrogen dioxide originate mainly from the burning of fossil fuels. In 2018, air pollution from fossil fuels caused $2.9 trillion in health and economic costs, about $8 billion a day.

Switching to clean sources of energy, such as wind and solar, thus helps address not only climate change but also air pollution and health.

- Renewable energy creates jobs: Every dollar of investment in renewables creates three times more jobs than in the fossil fuel industry. The IEA estimates that the transition towards net-zero emissions will lead to an overall increase in energy sector jobs: while about 5 million jobs in fossil fuel production could be lost by 2030, an estimated 14 million new jobs would be created in clean energy, resulting in a net gain of 9 million jobs.

In addition, energy-related industries would require a further 16 million workers, for instance to take on new roles in manufacturing of electric vehicles and hyper-efficient appliances or in innovative technologies such as hydrogen. This means that a total of more than 30 million jobs could be created in clean energy, efficiency, and low-emissions technologies by 2030.

Ensuring a just transition, placing the needs and rights of people at the heart of the energy transition, will be paramount to make sure no one is left behind.

- Renewable energy makes economic sense: About $7 trillion was spent on subsidizing the fossil fuel industry in 2022, including through explicit subsidies, tax breaks, and health and environmental damages that were not priced into the cost of fossil fuels.

In comparison, about $4.5 trillion a year needs to be invested in renewable energy until 2030 – including investments in technology and infrastructure – to allow us to reach net-zero emissions by 2050.

The upfront cost can be daunting for many countries with limited resources, and many will need financial and technical support to make the transition. But investments in renewable energy will pay off. The reduction of pollution and climate impacts alone could save the world up to $4.2 trillion per year by 2030.

Moreover, efficient, reliable renewable technologies can create a system less prone to market shocks and improve resilience and energy security by diversifying power supply options.

1.4 Project Vision:

Making Earth’s Rotational Energy Effective

The current challenge lies in developing innovative and scalable methods to capture and convert Earth's rotational energy into usable power. Our project will focus on exploring these possibilities, with the ultimate goal of harnessing Earth's kinetic energy in a way that is both efficient and sustainable.

1.5 Goals of the Project:

Investigating Feasible Methods: We will explore different approaches to capture the Earth's rotational energy. This could involve advanced turbine systems, large-scale flywheel generators, or new electromagnetic devices that could potentially harvest the Earth's rotational force.

Energy Storage and Conversion: One of the key hurdles is the conversion of this rotational energy into a form that can be stored and used. We will research technologies that can store kinetic energy and then convert it into electricity or other forms of power.

Sustainability: The project will aim to create a system that produces energy without significant environmental impact, complementing existing renewable energy sources like solar and wind. The idea is to create a sustainable solution that works alongside other green technologies to reduce our dependence on fossil fuels.

Advantage of the Motion: By tapping into the Earth's rotational energy, we can create a virtually limitless source of power. While capturing this energy on a global scale may be challenging, even small-scale implementations could provide significant advantages for specific applications, such as remote power generation, disaster relief, or as a backup energy source.

Earth’s rotational energy could be used to power isolated regions where traditional infrastructure is difficult to implement. This would be especially beneficial in places with limited access to sunlight or wind, but where Earth's rotation remains constant.

Energy Storage Systems: Large flywheels or other devices could store rotational energy during periods of peak efficiency and release it when demand is high, providing a buffer for energy grids.

Innovative Transportation: There is potential for the development of new forms of transportation that take advantage of the Earth's rotational force, reducing energy consumption and dependence on fuel-based power systems.

Sustainable Energy Grids: By integrating Earth's rotational energy with other renewable sources, we can build a more resilient and sustainable energy infrastructure, capable of supplying power even during periods of low solar or wind activity.

1.6 Challenges and Future Prospects

While Earth's rotational energy presents an exciting opportunity, there are numerous challenges:

Technological Hurdles: Capturing and converting rotational motion efficiently requires advanced materials and technologies that are not yet fully developed.

Environmental Considerations: There will also be environmental impacts to consider, particularly when implementing large-scale systems to capture Earth's energy. These systems must be carefully designed to avoid disrupting ecosystems or contributing to climate change.

Cost and Feasibility: The cost of developing such systems on a large scale could be significant. The economic viability of harvesting Earth's rotational energy will need to be assessed, along with potential market applications.

1.7 Conclusion

Earth's rotational energy is a largely untapped resource that offers immense potential. Our project will explore how this motion, which has been occurring for billions of years, can be effectively harnessed to create sustainable, renewable energy. By addressing technological, environmental, and economic challenges, we hope to unlock a new frontier of power generation, taking full advantage of the continuous motion of our planet and contributing to a more sustainable future.

2.1 Introduction

In This study, the energy from gravity will be introduced by a special design will be named as “Energy Wheel”. The design of the rotating wheel that operates using gravitational energy is based on the principle of dynamic balance and low friction to ensure continuous motion with acceptable efficiency. The energy wheel consists of a thin wooden disc with six copper tubes distributed with equal angles around the circumference of the disc. In each tube there are two rolling steel balls. The disc and the tubes sets on a central concentrated two bearings to reduce the friction and these bearings sets on a central non-rotating rod. The design revolves around harnessing gravity as the primary source of kinetic energy from a rolling steel balls, which requires precise manufacturing of mechanical components and ensuring the integrity of the parts for optimal performance. The device consists of several key components, each playing a specific role in achieving smooth and continuous motion. The following sections will briefly explain the components of the energy wheel.

2.2 Device Components

2.2.1 Main disc

At the beginning of the design; there was an expectation that the produced energy will be small due to the small masses of rolling balls. An iron bar forms the primary structure of the wheel, measuring 3.8 meters in length and carefully bent into a circular shape with an outer diameter of 125 cm. This circular structure ensures an even distribution of weight and forces during rotation, helping to maintain balance and stability. Because of the relatively high moment of inertia (which means a high power to move the circular bar. The mass of this wheel is 4.2 kg and a radius of gyration 62.5 cm (0.625 m). The inertia of this wheel is 1.641 $kg.m^2$. According to the Newton’s second law; the torque required to introduce a rotational acceleration (α rad/s^2) of 0.5 rad/s^2 which is required to continuous rotational movement is 0.82 N.m, since,.

$$\sum T = I\alpha \qquad (2.1)$$

Where T is the applied torque, I is the mass moment of inertia and α is the angular acceleration.

The manufacturing of this ring seems unsuitable due to its relatively high moment of inertia compared with produced torque due to rolling the steel balls which have a limited volume (radius with the internal radius of the pipes as will be explained later.

The steel ring then replaced by a wooden disc with 2.5 mm with a radius of 62.5 cm as can be seen in Figure -5. The mass of this disc is 840 gm (0.84 kg) with inertia of 0.135 kg.m^2. The mass moment of inertia of the disc was calculated as:

$$I = \frac{1}{2}mr^2 \qquad (2.2)$$

This small mass moment of inertia compared with the steel ring will be added to the mass moment of inertia of the copper pipes (tubes).

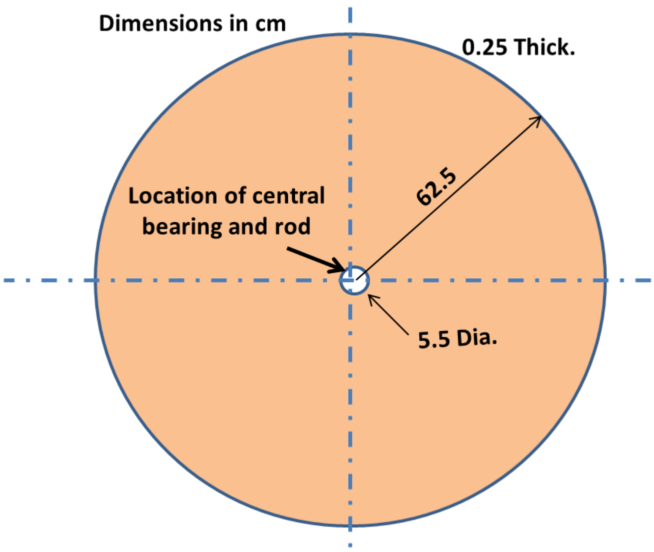

Figure -5 Dimensions of the wooden disc.

2.2.2 Copper Tubes

Six copper tubes with an outer diameter of 0.75 inch are used as pathways for the movement of 12 steel balls (two inside each tube), within the wheel. Copper is chosen for its excellent physical properties, such as corrosion resistance, and ease of forming, making it ideal for supporting internal motion without affecting performance. However, the relatively high mass makes them to some extent unsuitable and the easy manufacturing pushed toward using them. Replacing these tubes with a plastic tubes with larger radius will increase the introduced torque but, this obstacles by the difficulties of shaping the PVC tubes.

The length of the tube was 75 cm (0.75 m) and has S shape. Figure 6 shows the shape and dimensions of the copper tube. The two ends of each tube have been locked by a blind plastic cover to keep the rolling balls inside the tube.

The inertia of the copper tube (I_t) about their center of gravity (mid of the tube) can be calculated as:

$$I_t = \frac{1}{2} m_t l^2 \qquad (2.3)$$

Where, m_t is the mass of the copper tube and l is the tube length =0.625 m. This mass moment of inertia for six copper tubes was (0.01845 kg.m^2) and should be transformed to the end of the tube at the center of rotation as:

$$I_c = I_t + m_t * S^2 \qquad (2.4)$$

Where, I_c is the mass moment of inertia about the rotating center and S is the distance between the center of gravity and the center of rotation measured practically and found as (0.3 m)

There are six copper tubes thus the total mass moment of inertia will be (0.0271 kg.m^2).

The total mass moment of inertia is the summation of the wooden disc and the copper tubes moments of inertias. The bearings and their house and the central rod also had a mass moment of inertia but it will neglected due to their small radius and for safety, their moment of inertia will be consider as 10% of the total mass moment of inertia. The total mass moment of inertia is calculated and found (0.167 kg.m^2)

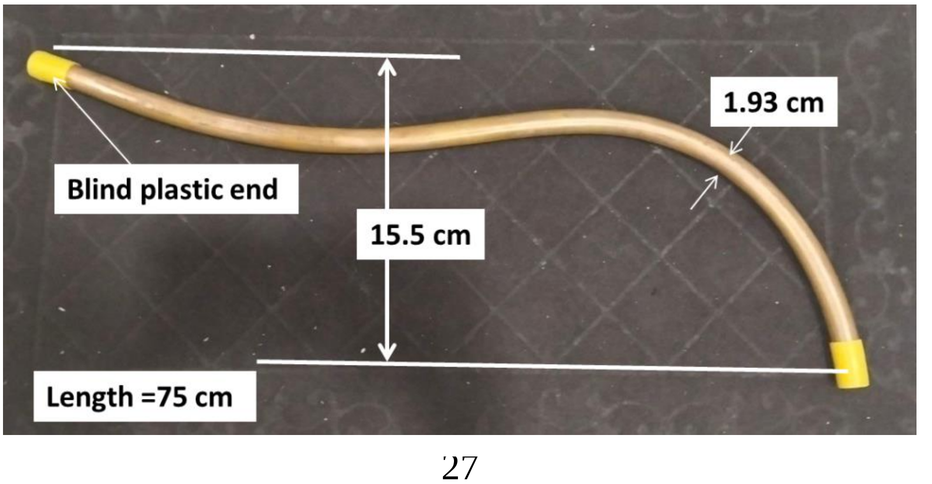

Figure 6 Dimensions of the copper tube.

2.2.3 Central rod

The non-rotating rod is 1.0 cm (0.01 m) diameter steel rod located at the center of the disc rotation. This rod is set on two coller bearings to reduce any additional friction from the bearings fixed on it. The central axis of the wheel rotates in alignment with the rod. It measures 24 cm (0.24 m) in length and serves as a connection between the outer frame (wheel) and the stationary base. This rod is preferred to be made of a strong, corrosion-resistant material to ensure smooth operation and a long lifespan. This rod with other components related to it can be seen in Figure 7.

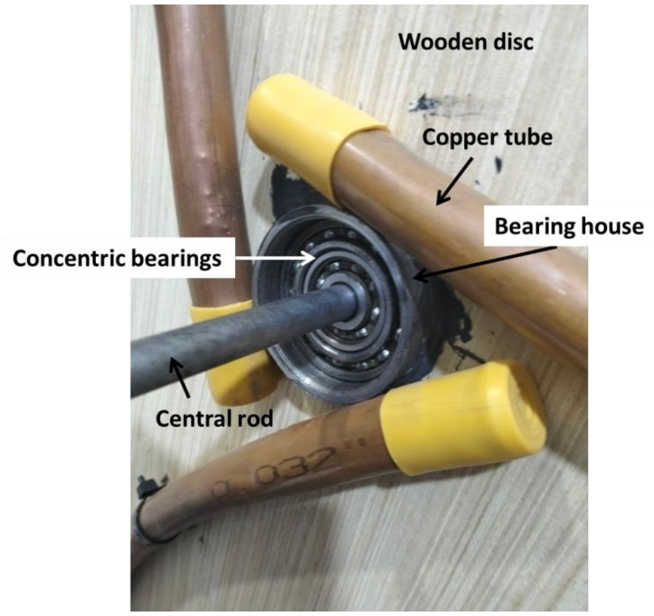

Figure 7 Central rod with other components.

2.2.4 Pair of Interlocked Bearings

To reduce the friction at the center of rotation; two interlocked bearings (concentric bearings) as can be seen in the previous Figure 7. This design includes a pair of interlocked bearings, ensuring smooth and stable motion of the rotating components. These bearings help minimize energy loss due to friction, contributing to continuous rotation with minimal resistance. The characteristics of the bearing used are illustrated in Table 1.

Table 1 Characteristics of the bearings used in the Energy Wheel.

Bearing ID No.	Inner race Dia. (mm)	Outer race Dia. (mm)	Thickness (mm)	Dynamic loading (N)	Life in million cycles
6906 GRS	30	47	9	7.0 kN	5.2
6200	10	30	9	6.8	8.0

2.2.5 Steel Balls

There are 12 steel balls placed inside the copper tubes (two in each tube). The steel balls play a vital role in enhancing weight distribution and achieving dynamic torque during the rotation. Two balls are placed inside the copper tubes instead of one ball was to increase the dynamic torque. Each ball weighs 16.0 grams and is strategically placed within the system, to optimize gravitational force. This distribution helps generating the necessary torque, contributing to sustained motion. It has been found that even using two balls (32 gm mass); the dynamic torque introduced due to the movement of these balls were not enough to produce the continuous rotational motion. The suggestion of using larger diameter of a plastic tubes instead of the copper with larger steel diameter and mass (92 gm mass). vThe large steel balls has not found in the market and we get them at the end of the project time limit . A sample of the used and the suggested steel balls can be seen in Figure 8. The torque produced by each ball will be discussed and calculated in the coming sections. The mass of the suggested steel balls is 2*287gm =0.564 kg.

Figure 8 The used and suggested steel balls should be placed inside the tubes.

2.2.6 Iron Base

The iron base serves as the foundation on which the wheel is mounted, providing complete stability to the system during rotation. The base should be designed to prevent unwanted vibrations and any non-preferred movements. Furthermore, enhancing the operational efficiency and minimizing energy loss are the other main purposes of designing the iron base. The base is made from a trade iron to reduce the cost of manufacturing this wheel. The rotating shaft is fixed into this base using collar bearings to ensure smooth and stable motion. The general shape and some important dimensions can be seen in Figure 9

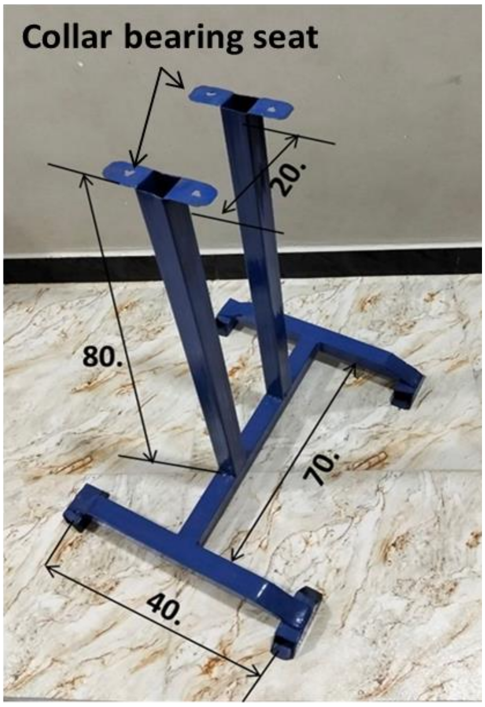

Figure 9 Iron base of the energy wheel.

2.2.7 Pair of Collar Bearings at the ends of the central shaft

An additional pair of collar bearings is used at the end of the central rod to support its attachment to the iron base. These bearings help in reducing the friction at the contact point between the shaft and the base, improving system stability and ensuring continuous motion with minimal resistance. The dimensions of the collar bearing can be seen in .

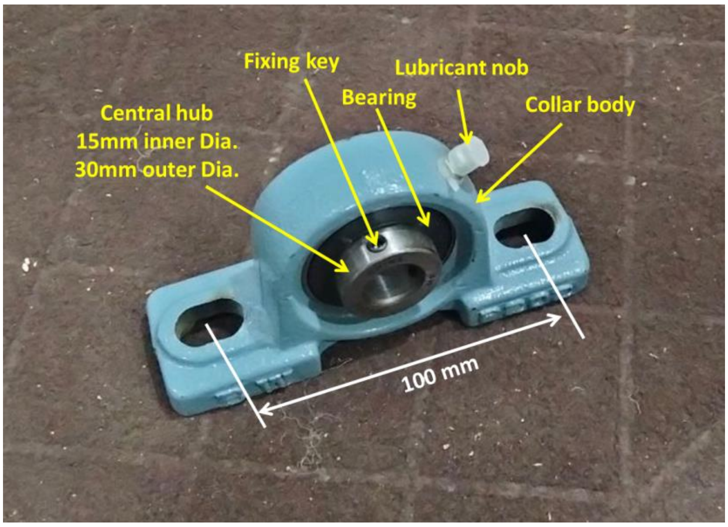

Figure 10 Details of the used collar bearing.

Four M13 bolts and nuts are used to fix the collar bearing and assembly the energy wheel. The general view of the wheel can be seen in Figure -11.

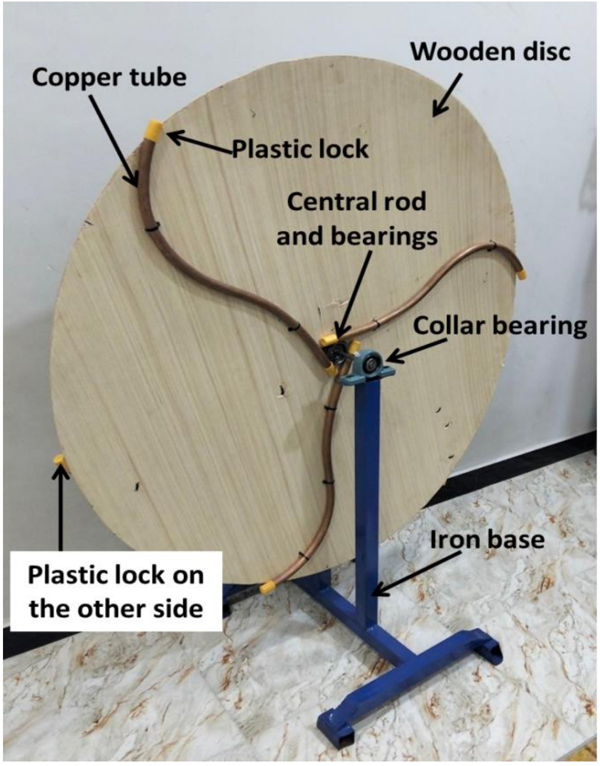

Figure -11 Assembly of the energy wheel.

2.3 Benefits of Bearings

Bearings play a crucial role in reducing friction and improving motion efficiency in mechanical systems. Their key benefits include:

• Reducing friction, allowing moving parts to operate smoothly and efficiently.

• Extending the lifespan of mechanical components by minimizing wear and tear caused by continuous friction.

• Enhancing energy efficiency by reducing mechanical power loss during operation.

• Providing support and stability for movement, ensuring the dynamic balance of the system.

2.4 Operating functionality

The energy wheel can not rotate without an initial rotational movement. This movement gives the initial rolling for the steel balls inside the copper tubes. Because of the continuity of the ball movements; the rolling balls will has a kinetic energy as velocity equal to potential energy introduced from the level difference between the maximum and minimum level of the start and end of the copper tube. The curvature of this tube has a special shape so, at the end of the tube, the rolling steel balls hit the closed end tangentially to increase the dynamic torque. The amount of forces and torques will be determined according to the calculation procedure will be explained with details in the following section.

2.5 Calculation procedure

The dimensions of the components are very important and the produced torque mainly depend on them.

The mass of rolling ball (m) can be calculated as:

$$m = \rho v \quad and\ v = \frac{4}{3}\pi r^3 \qquad (2.5)$$

Where, ρ is the steel density (7400 kg/m^3) and r is the radius of the steel ball r=11.75mm, m=16 gm.

The height of the ball falling is 15.5 cm (0.155 m), the ball velocity can be calculated from the converting of the potential energy (mgh = 0.016*9.81*0.155). This transfer to kinetic energy (1/2 m V^2 = 0.5*0.016*v^2). The velocity when the steel ball hits the end of the copper tube is (2.15 m/s).

The S shape of the copper tube also bring the steel balls towards the center of rotation that reduces the static torque (due to weight of the balls only since the copper tubes are symmetric at any position of the energy wheel.

The force due to hitting the steel balls can be calculated as:

K.E. =F*D (2.6)

$\frac{1}{2}mv^2 = F * 0.16$ and F=$\frac{1}{2}mv^2$ = 0.0243 N

The dynamic torque (T_d) about the center is:

$T_d = F * r$ (2.7)

T_d=0.0151 N.m

The static torque (T_s) also has amount which is equal to the multiplication of the weight of the steel balls by their distance from the center of rotation.

$T_s = \sum_1^6 0.016 * 9.81 * r_i$ (2.8)

Where, r_i is the individual distance of the steel balls from the center of rotation.

The angle between any two sequential copper tubes is 60^o; this angle can be divided into several angles to calculate the static torque at each position. Table 2 consists the values of T_s for the chosen angles. Since mass of the steel ball is constant (16 gm); the summation of distances of different balls will give the net static torque. This distance is the location of the steel balls from the center. The distance on the left half of the wheel will consider as negative (due to introducing negative torque) and on the right half of the wheel will be positive. The static torque from the weight of the copper tubes will be neglected due to symmetrical of the wheel at any position (angle).

Table 2 Static torque due to six copper tubes

Angle Θ (degree)	$\sum r_i$ (m)	T_s
10	**-0.333**	**-0.05226768**
20	**0.083**	**0.01302768**
30	**0.044**	**0.00690624**
40	**0.0005**	**0.00007848**
50	**-0.015**	**-0.0023544**
60	**-0.022**	**-0.00345312**

The maximum Total torque is (0.0151+0.083= 0.098 N.m). and the angular acceleration due to this torque is (0.587 rad/s^2) since the calculated mass moment of inertia was (0.167 kg.m^2). The minimum one is (-0.05226+0.0151=-0.0375 N.m) which gives an angular acceleration of 0.0378 rad/s^2).

The total static and dynamic torque are very small and the angular acceleration also very small that prevent the wheel from continuous rotational motion. This will be discussed in the following conclusion section.

2.6 Conclusion

This design demonstrates the integration of various components of a novel design of energy wheel. The components have been optimizes to ensure a smooth rotational motion utilizing gravitational force. Materials and components have been carefully selected to achieve dynamic balance and reduce friction, contributing to optimal efficiency.

The values of torques (static and dynamic torques) were very small that prevent the wheel from continuous rotational movements. This is due to the following reasons:

1) The small volume and mass of the steel balls that reduce the produced dynamic torque.
2) The copper pipes have relatively large mass and hence large mass moment of inertia.
3) Despite the hand work to manufacture the wheel components; it still have some errors in manufacturing the components especially the shape of the copper tubes.

4) The time facilities (very limited and busy time) prevent re-designing the components to avoid current problems.
5) Replacing the copper tubes with lighter and larger tubes with also larger steel balls probably will produced much benefit power as a rotational movement.

3.1 Introduction

In this chapter several tests of the energy wheel have been conducted to evaluate the output power as a profit from the primary rotating movement. The test includes two stages, the first of evaluating the actual mass moment of inertia and the second analyzing the torque to find the suitable weight for introducing continuous rotational movement.

3.2 Primary torque testing

This test is very simple , it consists of giving the designed wheel a primary rotational torque (as an initial movement) and observing the continuity of the movement. The test by conducting this test in two directions and observing the difference between each direction of rotation.

1. The first test is by giving an initial movement in the direction shown in Figure -12A. This initial test gives the energy wheel a movement to just starting the rotation and starting the rolling of the steel balls. This initial movement gives a continues movement for around three cycles then, the wheel stop with a pendulum movement in two directions. Despite the small movement, there is a profit of energy gives the wheel this periodic continuity; however, the wheel stops again due to its relatively high mass moment of inertia on one side and the small mass of the rolling steel balls which unable to gives the wheel its required continuity.
2. The second primary test is by giving the wheel a rotational movement in the opposite direction of the first test as can be seen in Figure -12B. This initial movement does not continue for a quarter of cycle and the wheel immediately stop from rotation and only a pendulum movement staying in the wheel but for shorter period of time compared with the first test.

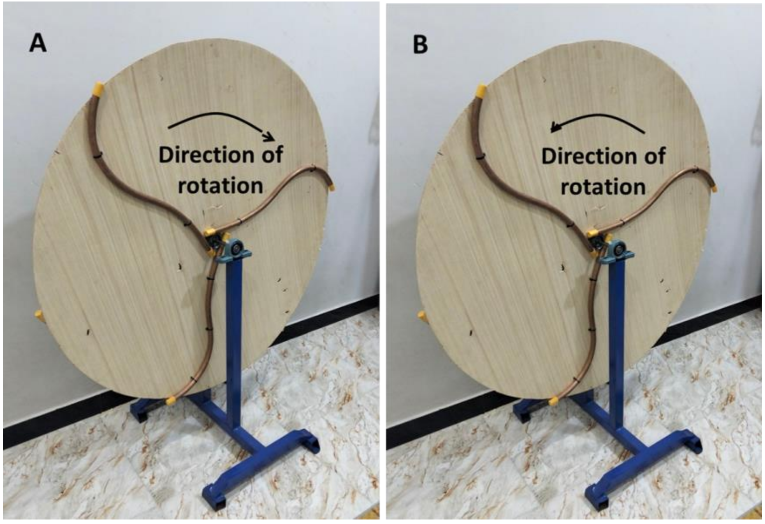

Figure -12 Two directions of the primary test.

The comparison of the two tests clearly shows a difference in the rotational movement between the two cases. This clear difference refers to that; there is a profit of energy from the torque of the rolling steel balls but the profit energy is very small due to using small steel balls and relatively high mass moment of inertia of the rotating wheel.

3.3 Hanging weight tests

These tests consisting of three individual tests by hanging a known mass with rob having a length equal to the distance between the rotating center and the ground. When this rob turning on the central rod and hanging a known mass at its end and letting this mass falls. The potential energy of the mass which is equal to the mass multiplied by its height will transfer into rotational energy equal to the mass moment of inertia of the rotating disc and its angular acceleration. When calculating the number of cycles after the mass fall and measuring the time for stop the wheel.

Three weights have been used which are (0.5 kg, 1.0 kg and 1,5 kg).The number of rotating cycles are different according to weight as illustrated in Table 3.

Table 3 Characteristics of the hanging weight tests

Hanged Mass (kg)	No. of rotation	Direction of test rotation
0.5	1.5	Clockwise (as in Figure 3.1A)
1.0	3.5	

1.5	**7.0**	
0.5	**0.5**	**Anticlockwise (as in Figure 3.1B)**
1.0	**1.5**	
1.5	**3.0**	

The presenting of these data can be seen in Figure 13. It is clear that, the number of rotation after falling the hanged test mass increased with increasing the mass. This means increasing the mass of the rolling steel balls will increase the torque and probably produce a continuous movement.

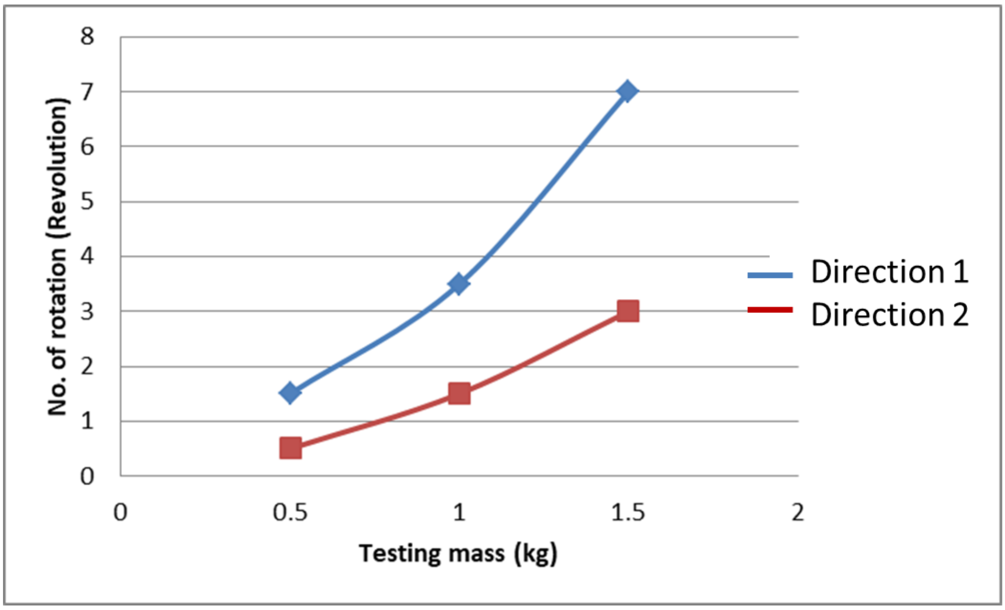

Figure 13 Results of testing the wheel in two directions with different masses

3.4 Discussion

The results of testing the gravity energy wheel presented in Figure 13 showed two tests in two directions, the first towards the planned increase the torque and the second in the opposite first direction. There is an increase in the number of rotation with increasing the mass due to increasing the torque applied on the wheel to produce the initial movement. This incremental relation is not linear and this means that, the increasing of testing weight will gives increasing energy to give the initial movement.

The wheel stops after a number of cycles due to small mass of the rolling steel balls and the relatively high mass moment of inertia; however, there is a clear difference between the planned direction of rotation and the opposite direction which means there is a profit of the rotational energy in the designed direction and this profit of energy can be significantly increased with increasing the steel rolling balls.

The profit of the energy is small but, the profit of energy from only the gravity energy can be achieved. This subject is very important and requires more studies to evaluate the economic benefits from designing and manufacturing such system and this project is just the trigger towards thinking about using the gravity energy as a source of producing a cheap and clean energy.

4.1 Introduction

This project represents a first step toward harnessing the Earth's gravitational energy to drive a rotating wheel, which can be the basis for generating clean mechanical energy. Although the current design does not achieve continuous rotational motion based solely on the weight and energy generated by the steel balls, the experimental and analytical results obtained provided a solid foundation for many future improvements and developments. Accordingly, we recommend several recommendations for future work, as follows:

4.2 Improved Geometric Design

Increasing the steel ball mass: It is recommended to use balls with a larger mass, as this has a direct impact on increasing the resulting torque and achieving higher kinetic energy.

Expanded pipe diameters and replacing the copper pipes with plastic pipes with a larger inner diameter allows for the use of larger balls, thus increasing the resulting profit torque.

Redesigned the pipe curves and modifying the shape of the pipes to be steeper at the landing point to increase the balls' terminal velocity and thus increase the dynamic torque upon impact.

4.3 Improved Materials

Replaced Wood with lighter and stronger materials will reduce the weight. The high-strength composite materials could be used instead of wood for the wheel disc, reducing the torque required to initiate movement.

Choosing lower-friction tubes: Using materials with a low coefficient of friction to reduce the resistance to ball movement within the tubes.

4.4 Integrating assistive technologies

Using a start-up assist system: such as a small motor to generate an initial motion, then allowing the system to operate under gravity after the equilibrium point is reached.

Storing the resulting energy: The system can be developed to include a small electric generator to store the energy generated by the partial wheel motion, allowing the energy to be used later to operate the assist systems.

4.5 Improving mounting and support methods

Increasing the stability of the steel base: Improving the mounting system to reduce vibrations and prevent energy loss.

Using high-quality axles and bearings: These significantly reduce friction and increase rotational efficiency.

4.6 Environmental and safety study

Environmental impact analysis: When developing the project for larger-scale operation, the potential environmental impact of the system must be studied, especially when using heavy or rapidly rotating materials.

Ensuring mechanical safety: Especially with increasing mass and speed, preventive measures must be put in place to ensure that parts do not become separated or cause dangerous collisions.

4.7 Possibility of Converting the Wheel to a Generator

Studying the Connection of the Wheel to an Electric Generator: When continuous or near-continuous rotation is achieved, the wheel can be connected to a generator to produce usable electrical energy.

Using the System as a Backup Power Source: In emergencies or in remote areas, it can be developed into an environmentally friendly backup system.

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