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# The Systems of Mathematical Functions as Input Strategies for Contemporary Industrial Product Design

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***Abstract***

*This research emphasizes the crucial role of functions in elucidating physical relationships and diverse applications across scientific domains, particularly in the realm of design. The study investigates the contemporary and applied nature of design methodologies, employing real mathematical functions in the creation of industrial products within an organizational framework. The primary objective is to delineate the systems of functions (inputs and outputs) in industrial product design based on a well-defined strategy. The theoretical foundation encompasses design strategy and its correlation with applied scientific disciplines, elucidating key function types and their systems in industrial product design (inverse function, constant function, and quadratic function), as well as the kinematics of industrial products. The research findings highlight that mathematical functions serve as organizational strategies derived from kinetic equations, offering the requisite configuration (position and rotation) for product movement. Designers rely on specific functions, considering both essential functionality and overall form. Moreover, these functions are integral to formulating strategies that facilitate the seamless integration of shape and function. This study contributes valuable insights into the strategic aspects of industrial product design, emphasizing the pivotal role of mathematical functions in achieving a harmonious synthesis of form and function.*

***Keywords:*** *Mathematical Functions, Starting Point, Stability, Inverse Kinematics.*

## INTRODUCTION

The mathematical function in the design of the form and function of the industrial product adopted a new approach in designing products of this type, highlighting its connection with sciences, particularly mathematics and physics. This connection reached the point of linking function and form through mathematical relationships and systems, involving various inputs from specifications and various materials, and generating new entity outputs. In any design system, functions represent the relationship between inputs (elements, principles, relationships) and outputs (shapes, structures, functions) with evolving variables. Various types of functions have emerged, taking on diverse forms and structures. (M.J, 1990, p. 123).

In any design system, functions represent the relationship between inputs (elements, principles, relationships) and outputs (shapes, structures, functions) with evolving variables. Various types of functions have emerged, taking on diverse forms and structures. Among the most common types of functions in the design system are: Inverse Function, Static Function and Quadratic Function.

### Research Problem

The mathematical function has introduced new dimensions and has created functional ideas, solutions, and aesthetic elements that were not previously present. Given the significant advancements that have elevated industrial design to the level of breakthroughs, these mathematical applications have been leveraged to enhance product development and formulate new ideas that were previously unattainable through traditional means. It has become possible to implement these ideas, regardless of their complexity, by relying on mathematical principles and laws. Various countless types of mathematical functions have subsequently emerged, each with multiple inputs and outputs tailored to fit the function and form.

Thus, the research problem develops in the following question: **What are the modern and applied design methodologies using a clear mathematical function in the design of industrial products according to organizational strategies?**

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**Research Objective:** Identifying the systems of functions in the design of industrial products according to a well-defined strategy.

**Term Definition:**

**Function Systems and Mathematical Function**: In mathematics, functions represent a relationship between inputs and permissible outputs, with the property that each input is associated with only one output. It is possible for an output to be associated with more than one input, and conversely, more than one input may be associated with a single output. Assuming that A and B are two non-empty sets, the assignment from set A to set B is considered a function only when each element in set A has a unique counterpart and a single image in set B.

Reference: [Link to Source]

**Procedural Definition**: The mathematical function in industrial product design is a strategic organization of design elements, principles, and relationships with mathematical dimensions. It involves functional solutions and aesthetic elements presented in new mathematical formulations and dynamic directions that align with both the function and form of the industrial product.

**Theoretical Framework:**

**Strategic Design**

The traditional concept of design is intricately linked to the inherent nature of a product and is often associated with specific names. The strategic addition expands this notion, connecting creativity with innovation and technique. This allows ideas to evolve into practical applications in the realm of industrial product design, adaptable for use or implementation by the end user. Strategic design draws from various sciences that have emerged in recent years, defining the principles of strategic design by providing new insights and methodologies across multiple fields. In recent years, complex and interdisciplinary strategies have emerged, intertwining with various cognitive sciences such as mathematics, physics, and chemistry. Their relationship with applied sciences has become apparent, leading to converging points, including differentiable functions and curves.

**Figure 1**

The industrial product according to inputs of curves and mathematical functions with design, structural, and kinetic outputs

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And this relationship is reflected on the design, and what was aptly termed as function systems. Deliberate attempts were made to explore the capabilities of these systems in industrial design and in overcoming the constraints of traditional design methodologies. This involves the potential transformation of old design paradigms and the possibility of incorporating new configurations that reflect the characteristics of these systems. It involves navigating the inherent relationship between form and function in product design in various ways according to its design requirements, structure, and dynamics.

One of the significant challenges is finding integration between them, considering them as a unified entity in contemporary design beyond the levels of form, structure, or function, as mentioned in reference 1. This integration must align with function systems, combining inputs with design processes and producing outputs according to suitable configurations for the type of product. The nature of the system, whether repetitive, inverse, symmetrical, etc., must be determined.

In 1441, the English mathematician Gottfried Leibniz succeeded in defining the relationship between two curves and their slope at a specific point. He explained this in what is now known as functions (Kassem Al-Ma'mun, 2002, p. 23), which were later categorized into various types, each governing specific variable.

**There are different types of functions in mathematics, each with unique characteristics and constraints, making them selectively suitable for product design. The three most commonly used functions in product design are:**

**Inverse Function**: The inverse function reflects the characteristics of the original function onto the corresponding domain. In the case where the function is symmetric from A to B, the inverse function becomes symmetric from B to A, as illustrated in Figure (2). The designer utilized the inverse function to create a dual design that varies the directions (input values) at the interface between two surfaces. This separation defines the middle ground between two environments, with the directions reversing towards the center point. An application of this design can be seen in the dual design of hot and cold-water faucets.

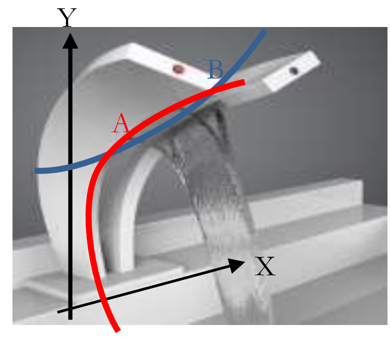


**Figure 2**

Inverse Function in Shower Design

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**Static Function:** Static function is a function whose design relationships are intentionally fixed, providing no variation in the function's value, as depicted in Figure (3). In this example, the fixed elements in the kitchen design include the sink and water fixtures, and any changes in the direction of the food tray do not signify a fundamental alteration in the overall system of fixed elements. Instead, it follows another function, namely the inverse function. More precisely, it implies that any movable values for the sink are dependent on the primary function (basic function), and the change in the direction of the food tray reflects the inverse function.

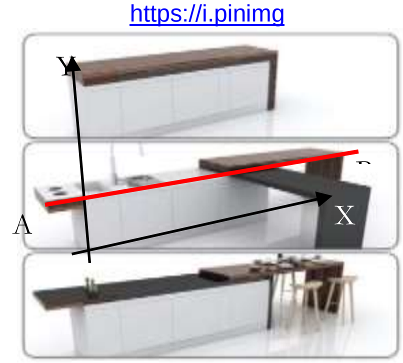
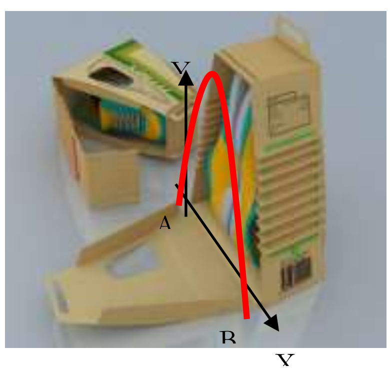



**Figure 3**

Static Function in Modern Kitchen Design

**Quadratic Function:** The quadratic function, it is a multi-boundary function with one or more variables (Gott, 1991, page 64). This function has been applied in the designs of packaging and wrapping, diversifying the boundaries of package design, as illustrated in Figure (4). The single variable in this case is the form of the product. For instance, the function can take the shape of the product as elliptical, circular, triangular, etc. These functions redefine the tasks and duties of the industrial product by assigning additional functions and tasks within the scope of the same function. In other words, it involves deepening the function alongside the form. This enhances the overall appeal and attractiveness, adding various tasks. This design approach provides a greater degree of freedom for the user based on function systems. It is essential to align these functions with the external capabilities and possibilities of the product. The accuracy of the design approach, satisfaction with external factors, and functional stability, whether for an individual product or a collective one, contribute to user satisfaction. Excessive complexity in the function type can lead adverse results by confusing the user due to increased diversity and complexity of the function type. Therefore, there is a need for a specific mathematical function that aligns with the form of the industrial product.




to

**Figure 4**

Packaging with the Application of the Quadratic Function for a Single Variable, Shaping the Product

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### Functions and the Industrial Design System

In any design system, functions represent the relationship between inputs (elements, principles, relationships) and outputs (shapes, structures, functions) with evolving variables. Various types of functions have emerged, taking on diverse forms and structures. Among the most common types of functions in the design system are:

### 1- Inverse Function System

The inverse function is a strategic approach where the function is regarded as one that can be systematically reflected into another function. In simple terms, if any function, let's call it "F," goes from A to B, then it is inverse; "F inverse" takes B back to A. If the function is denoted positively on the Cartesian plane, its inverse function is indicated by "-F," negative on the same graph, as illustrated in Figure (5).

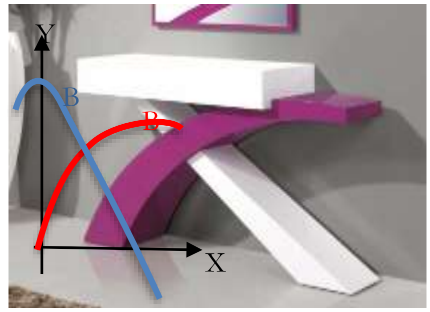


***Figure 5***

Console with the Design of the Inverse Function: The Purple-Sided Base and Let's Assume a Function (F) from X to Y, Its Inverse (White Side) from Y to X https://i.pinimg.com/.jpg

In robotics, inverse kinematics benefit from kinematic equations to determine common parameters, mathematical and computational information for each motion required by the product, whether it's mechanical or directional motion, etc. These equations provide the required configuration (position and rotation) for each robot's final positions, for example, as shown in Figure (6), a hexapod DIY robot with a free structure of 340 degrees. Determining the robot's motion involves moving the final positions from the initial configuration to the desired configuration using motion planning. Kinematics (M.J, 1990, p. 77) transforms the motion plan into joint trajectories for the robot. This set includes all electronic components, a motor, and an infrared sensor.

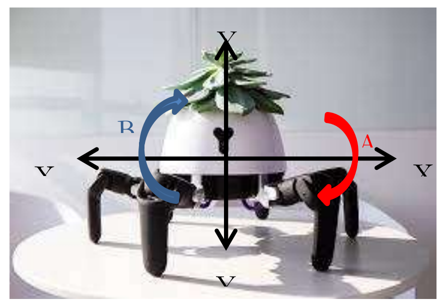


**Figure 6**

The Hexagonal Robot and the Motion of the Inverse Function

**Kinematics and Inverse Function**: Kinematics, the study of pure motion or kinetics, is a branch of mechanics that focuses on understanding the physical motion of bodies without considering the causes of motion, such as mass or forces. It is also referred to as motion engineering and stands in contrast to dynamics, which deals with forces and interactions that produce or affect motion (Abbadi-Al, 2016, p. 19). Kinematics explores how the position of a body changes over time, measuring the position relative to reference points.

For example, in sewing machines as shown in Figure (7), the mechanical motion represents the relationship between the motion of the needle and the motion of the axis, defined by the interaction between the needle thread and the bobbin thread at a controlled time rate and speed. In the context of robotics, the study of kinematics is crucial for inverse functions, especially in determining the configuration and motion planning for robots, as mentioned earlier in the discussion of the inverse function system.

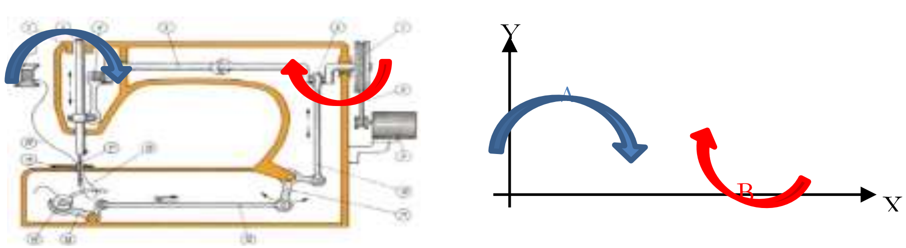


**Figure7**

The Significance of Sewing and Kinematic Movement

Speed and acceleration are two fundamental quantities that describe how position changes over time. Speed is the rate of change of position (with respect to time), while acceleration is the rate of change of speed. Therefore, speed and acceleration are the primary quantities that describe how time changes with position.

**Industrial Design and Inverse Kinematics:** In computer-aided graphics, parametric engineering robots, and the geometric parameters of articulated structures, inverse kinematics is the mathematical process of moving forward versus backward to calculate parameters. It involves formulating new expressions to calculate variable quantities during motion and at rest in any necessary function. In the context of the common variable functions, the source of mathematical position for the end of a motion series, such as the robot's maneuvers or the skeletal structure of an animated character, is typically calculated using the common parameters. This can often calculate the position and direction of the end of the series directly using various applications of trigonometric formulas, a process known as kinematics.

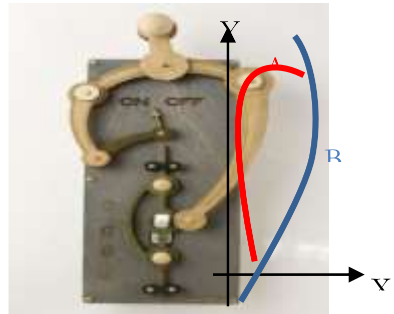


**Figure 8**

The Internal System of Inverse Kinematics

Inverse kinematics has found particular significance in industrial design, evident in products such as the innovative key covers developed by Green Tree Jewelry, as illustrated in Figure (8). The company created a series of wooden light switch covers for homes, incorporating gears, levers, and pivot points to complicate the operation of the switch excessively. The mathematical motion process on the left versus the inverse process for calculating the necessary variable parameters for the position of the end of the motion series to the right, as seen in Figure (9), is a striking scientific application within industrial design.

Therefore, the function in which the field values are inverted is the inverse of the corresponding field values. In other words, if $F$ is a symmetric function from $A$ to $B$, then the inverse function $-F$ from $B$ to $A$ is the inverse function that reflects values in the corresponding domain.

In the context where $F$ is a symmetric function from $A$ to $B$, the inverse function $-F$ from $B$ to $A$ is the inverse function that reverses or transforms the original function. If a function is inverse, then this function has a reciprocal or inverse function, and it can be a one-to-one mapping.

As illustrated in Figure (9), the scientific application of the inverse function is demonstrated in the analysis of fluids. When studying the flow of liquid, the inverse function is used to examine reflections and factors influencing the movement of the fluid. This highlights how mathematical concepts can be applied to understand and enhance design in various fields of industry and science.

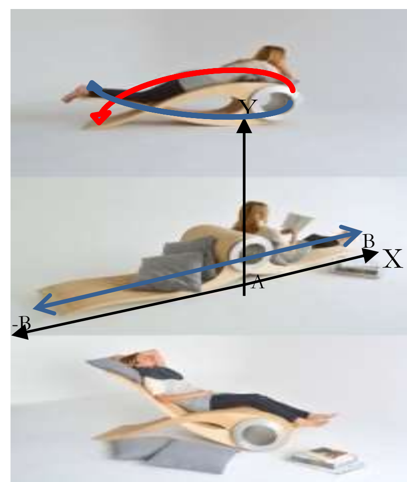


***Figure 9***

The Scientific Application of the Inverse Function on a Seating Unit

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**2- Static Function**

In mathematics, the term "static" refers to something that does not change, and it can carry different meanings. It may indicate a fixed value or a concept in reinforced lightweight restoration objects in the field of civil engineering, particularly in the context of addressing shear deficiencies in concrete bridges using carbon fiber-reinforced polymers (Hamed, Restoration of lightweight reinforced concrete bridges that suffer from shear deficiencies using carbon fiber-reinforced polymers, 2023, p. 47). This usage is sometimes distinguished from other meanings.

Moreover, the term "static" can also refer to a constant function or its value. This constant is typically a variable that does not depend on the main variable in studying a particular problem. For example, in the case of definite integration, where the constant is an arbitrary constant (not depending on the integration variable), this is distinct from the reverse derivative, which is specific for obtaining all the inverse derivatives of the given function (Jawad, Kinetic analysis of bridge floors using the finite element method, p. 42).

As depicted in Figure (10), the organized strategy for the static function in the design of a product, such as a chair, has two sides. The first side involves considering the support structure of the product, along with the specific inverse derivative. The second side emphasizes that the design should be in accordance with a specific fixed number, aligning with the nature of the human body and ergonomics.

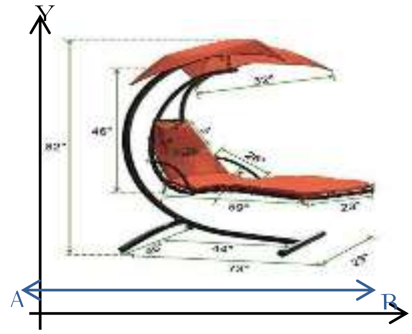


***Figure** 10*

A seating unit with a constant function, as illustrated in the graphical representation of the constant function

**The Quadratic Function**

Quadratic functions are used in various fields such as geometry, design, and different sciences to obtain values represented by equivalent parameters graphically (Haidari-Al, 2005, p. 44). Depending on the coefficient of the highest degree, the direction of the curve is determined. In other words, the quadratic function is a "multi-bounded function of the second degree". There are many scenarios where quadratic functions are used, for instance, when launching a rocket whose trajectory is determined by solving a quadratic function (see Figure 11).

In the design of a seating unit with a quadratic function, as illustrated in the graphical representation of the static function, the quadratic function is a multi-bounded function with one or more variables, where the highest power of the variable is two. This function, also known as a quadratic function, has at least one limit, which is of the second degree. It is a polynomial function.

Quadratic functions are used in daily life, as well as in science, business, and engineering. They play a crucial role in packaging design to minimize waste. Quadratic equations can be employed to determine maximum and minimum values for various designs, such as speed, cost, and area, as shown in Figure 11. This means that we can use quadratic equations to analyze these structures and use graphical representations to easily determine maximum and minimum values and when the outputs are equal. In packaging design, as highlighted in Figure 11, the maximum values are equal between the base and its height, and between the cover's length and its width, leading to the point of intersection and subsequent connections.

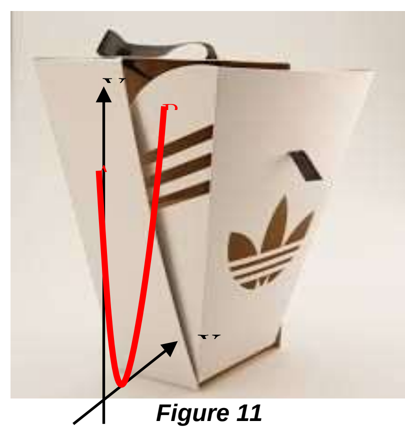

***Figure 11***

The quadratic function in packaging design

## METHODOLOGY

The researcher adopted the descriptive methodology in analyzing the sample to achieve the objectives. Descriptive methodology is one of the most common and widely used approaches in design research.

**Research Community:** One of the communities that adopts organized strategies and benefits from various sciences is the future automotive industry, including companies such as Chevrolet, Mercedes, and Toyota.

**Sample Analysis**

**Example Number 1:**

**First: The Description**

| | |
|---|---|
| **Overview** | Operates on electric power from Chevrolet |
| **Model** | 2024 |
| **Country of Manufacturing** | America |
| **Car Description** | The exterior color of the car is yellow, while the glass is transparent black with a dark black color on the front of the car. Additionally, broken lines are added on the sides in black color. |

**Second: Analysis**

The mathematical function in the design of the form and function of the industrial product: Chevrolet Motors, which adopted a new approach in designing products of this type, highlighting its connection with sciences, particularly mathematics and physics. This connection reached the point of linking function and form through mathematical relationships and systems, involving various inputs from specifications and various materials, and generating new entity outputs. The designer utilized kinetic equations to determine common parameters that provide the required configuration (position and rotation) for the upper part of the car and the lower part of the base, as well as the motion of the doors. Through the relationship between curves and the slope at a specific point, the mathematical representation of the external car body, according to the mathematical function, involves an inverse function with representations of curves for the upper part and a constant function for the base, stabilizing the overall shape.

**Example Number 2:**


**First: The Description**

| | |
|---|---|
| **Overview** | The car is from Mercedes |
| **Model** | 2024 |
| **Country of Manufacturing** | America |
| **Car Description** | The car is in a celestial silver color with a clear prominence of the tire size and the integrated door handles. The doors open upwards. |

**Second: Analysis**

The intellectual dimensions and theoretical frameworks associated with the function's domain, intersecting with the design of this car, led to a comprehensive discussion of intentional and deliberate functions that shape this car through its overall appearance. This is represented by the repeated curves of each door and the general structure of the car. The changing perspective of the nature of industrial development and integrated systems reflects changes based on the complete integration of diverse inputs and processing technologies, resulting in various outputs. The evolution of the Mercedes car is evident in the type of inputs and the programming of outputs with design processes that contribute to the characteristics of uniqueness in shape and the transparency of doors. For example, we find this case in the integration of the function, which is a primary function (the overall system), not according to the integration variable but the internal and external environment variables. Additionally, the inverted derivative is specialized to obtain modern technology for doors and all the inverse derivatives for the given function.

**Example Number 3:**


**First: The Description**

| | |
|---|---|
| **Overview** | **The car is from Toyota** |
| **Model** | **2024** |
| **Country of Manufacturing** | **Japan** |
| **Car Description** | The front doors of the car, which is of a celestial silver color, open upwards with a distinct prominence of the wheels and the descending line. As for the rear doors, they are covered with a sleek cap that extends along the car's structure. |

**Second: Analysis**

Through the relationship between two curves and the specific slope at certain points, the mathematical representation of the motion of the car door, according to the inverse function, is achieved. Additionally, the inverse kinematics, where the field elements for the right door of the car are inversely related to the field elements for the left door, constitutes the inverse function for the coupling.

Inverse kinematics technology has been adopted in the design process as a simple yet effective method for the development of certain products. In inverse kinematics, there may be variable parameters controlling the forward motion equation, such as joint angles, lengths, or other intersecting real values. Graphical representations of quadratic functions have been used to determine information about maximum and minimum values easily, as well as when the outputs are equal, governing the smooth operation of the doors in packaging design. Specifically, in this sample, the maximum values vary between the doors, their heights, depths, and the overall structure of the car, leading to a point of convergence and balance.

## RESULT AND FINDINGS

The Kinematic mathematical modeling is a systematic and strategic approach using motion equations to provide the required configuration (shape and rotation) for product movement. It depends on a specified function, balancing the fundamental function and the overall shape.

A crucial strategic approach involves integrating the form and function as one unit. This integration must adhere to a function determined by mathematical parameters and motion directions, designed accordingly.

Inverse kinematics serve as the inverse mathematical function. Variable elements control the forward motion equation and the reverse, representing the product's function. These variables could be joint angles, lengths, or other real values.

The mathematical function is expressive, representing names, elements, and relationships with new mathematical and directional expressions. It aligns with functional capabilities, enhancing them through the formation of shapes and structures that reflect the function type.

For each product, there is a designated function and a starting point. The principle of the designated function and what is built on it, either the product name or the designated function, acts as a foundation. The starting point involves new movement and design techniques that align with the function type and the internal and external environment.

## REFERENCES

J.M. McCarthy, **An Introduction to Theoretical Kinesiology**, MIT Press, Cambridge, Massachusetts.- 1990.

Al-Haidari, Sana Sati', Sahar Hilal**, "The Fractional City,"** a research published in the Journal of the Association of Arab Universities for Engineering Studies and Research, Issue (2), Volume (12), 2005.

Shereen Hamed, **Restoration of lightweight reinforced concrete bridges that suffer from shear deficiencies using carbon fiber reinforced polymers,** a published master's thesis submitted to the College of Engineering, University of Karbala, 2023.

Al-Kasabiyyah, Hassan Abd Ali**, "Euclidean Geometry in the Architecture of Urban Systems,"** a PhD thesis submitted to the Department of Architectural Engineering, University of Baghdad, 2005.

Huda Jassem Jawad, **"Kinetic Analysis of Bridge Floors Using the Finite Element Method",** a published master's thesis, College of Engineering, University of Basra.

Wameed Abdel-Karim Mohsen, **Distinctive Design and Its Strategy in Product Design**, Middle East Research Journal, Article 8, Volume 10, Issue 75, May 2022,

Al-Abbadi, Difaf Ghazi Ayas, Beautiful **Dynamics, University and its Engagements in Designing Industrial Products for the Third Millennium,** a thesis submitted to the Council of the College of Arts, Baghdad, 2016.

Gott, L Pollard, **"Fractal repetition in the poetry of Wallace Stevens**," Language and Style 19, 1989.

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https://www.alloschool.com/element/55287
https://www.hindawi.org/books/80460295/1/
http://aghandoura.com/1/Third%20secondary%20c1/Chapter%201/Lesson%207/Exercises/ex2/
http://curious.astro.cornell.edu/question.php?number=4
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https://mathworld.wolfram.com/Reflection.html