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Geometric Foundations of Engineering Design: The Role of Conic Sections Enhanced by Artificial Intelligence

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Abstract

Many branches of engineering rely on four fundamental geometric shapes: circle, ellipse, parabola, and hyperbola, whose intrinsic properties enable engineers to develop more accurate mathematical models, optimize trajectories, and enhance structural integrity in complex design contexts. This study examines how these classical conic sections are applied in real-world engineering problems and explores the utilization of geometric principles in robotics, signal processing, and automated systems to support efficient problem-solving. By relating the properties of conic sections to engineering requirements in areas such as bridge design, trajectory optimization, and structural analysis, the study elucidates how these forms underpin both analytical modelling and practical implementation in contemporary engineering practice. The analysis shows that the relevance of conic sections to practical engineering applications is clearly demonstrated across multiple domains, highlighting their role in improving modelling accuracy, guiding system optimization, and informing robust design strategies. The study concludes that classical geometry, particularly the theory of conic sections, continues to play a vital role in shaping modern engineering practices and carries important implications for advancing engineering education, promoting interdisciplinary integration, and sustaining innovation in technology and infrastructure development.

Keywords: Conic Sections; Geometry in Engineering; Structural Design; Robotics and Automation; Signal Processing.

Introduction

Conic sections are important curves in geometry that are formed when a plane cuts a cone. These curves include the circle, ellipse, parabola, and hyperbola. Although they are studied in mathematics, their u se is found in many engineering fields. Engineering's apply these shapes in designing structures, controlling motion, improving communication systems, and creating machines that work more efficiently. Today's engineering work depends a lot on accurate models and correct measurements. Conic sections help in understanding. How objects move, how light reflects, and how forces act on different structures. Because of this, they are used in are a like civil engineering, mechanical design, aerospace, electronics, and architecture. Along with this, geometric ideas are also becoming important in modern technologies like Artificial Intelligence. When AI systems analyse shapes, paths, or patterns, geometry helps them make better decisions. In this way, classical geometry and new technology work together to improve engineering solutions.

Literature Review

Analytical geometry and artificial intelligence (AI) have made significant contributions to the fields of architecture, engineering, and applied mathematics by enhancing design, optimization, and decision-making processes, as evidenced in the existing literature. Modern spatial design is grounded in mathematical logic and geometric modeling, as demonstrated by seminal works in algorithmic and digital design that promote rule-based and computational thinking in architecture (Terzidis, 2006; Weygant, 2011). In contrast, research in housing and interior design focuses on maximizing limited space and storage efficiency in urban environments (Zimmerman & Martin, 2001; UN-Habitat, 2012). Recent journal studies further confirm the continued relevance of analytical geometry in real-world applications, including modular furniture design, under-staircase storage optimization, urban housing efficiency, suspension bridge design, aerial navigation, and architectural aesthetics (Khan & Kumar, 2019; Shrestha & Gurung, 2021; Mishra & Sahani, 2024; Pandey et al., 2025; Thakur et al., 2025). By integrating classical mathematical principles with artificial intelligence and machine learning techniques particularly neural networks and AI-assisted optimization—Sahani and collaborators have significantly extended the scope of analytical geometry to nonlinear systems, differential equations, forecasting, and diverse engineering applications (Sahani, 2021; Sahani et al., 2023; Sahani & Sah, 2024). Moreover, contemporary studies in mathematics and engineering management demonstrate that intelligent algorithms improve system governance, operational efficiency, and modeling accuracy (Bhattarai et al., 2025; Sahani et al., 2025), supporting a more integrated analytical framework. Overall, the literature reveals a clear trend toward the effective combination of analytical geometry and AI, where geometric rigor provides a solid mathematical foundation and artificial intelligence offers computational power and adaptability for solving complex real-world problems in design, engineering, and applied sciences.

Objectives:

1. To study the impact of conic section in civil engineering.
2. To analyse how AI uses geometric principals to improve structural designs.
3. To explore real-life examples in conic sections in engineering projects.
4. To provide visual examples demonstrating the practical impact of conic sections in modern civil engineering projects.
5. To examine real-life applications of conic sections in bridges, arches, roofs, tunnels, and towers

Applications of conic sections in engineering fields.

Conic sections, including circle, ellipse, parabola, and hyperbola-play an important role in engineering. These curves help engineers design strong, efficient, and stable structures. They are used in civil engineering, mechanical engineering, electrical engineering, aerospace engineering, and even AI-based design systems.

Here are the major human-level applications of conic sections in engineering:

1. Circle:

The circle is widely used in engineering because it distributes pressure evenly in all directions. This makes circular shapes ideal for pipelines, tunnels, and water tanks, where uniform stress is important for safety. Circular components such as wheels, gears, bearings, and shafts ensure smooth rotation in machines. Circular columns and towers also provide greater stability because there are no weak corners. Due to their symmetry, circular shapes are easy to analyse mathematically, making them a preferred choice in many engineering structures.

Fig circle:

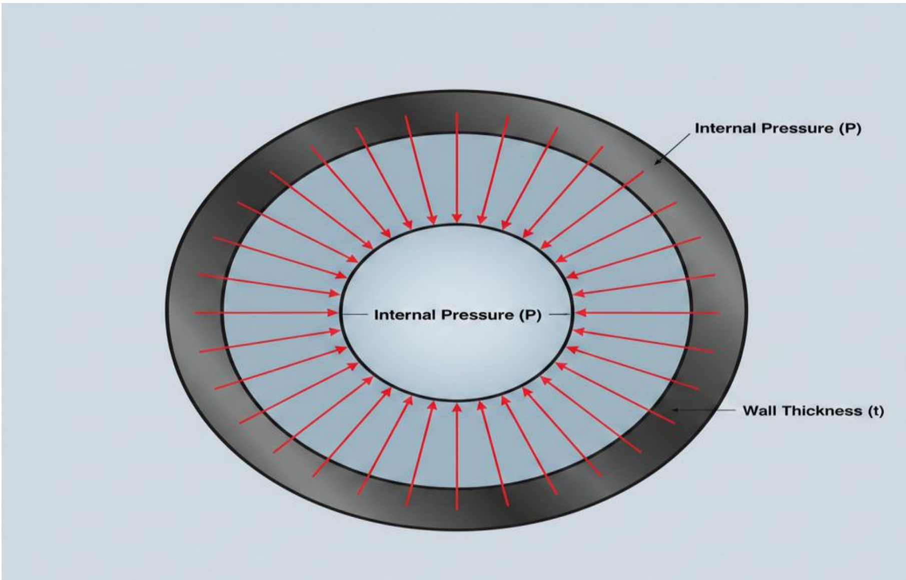


Figure 1: Cross-sectinal view of a pipe showing uniform internal **pressure distribution** ($P) acting radialy outwards, outwards, **highaliging key geometric parameters (d, t).**

This figure demonstrates how a circular cross-section ensures equal pressure distribution in all directions. Due to this uniform stress behaviour, circular shapes are preferred in pipelines, storage tanks, and mechanical components for enhanced safety and stability.

Problem 1.

How do conic sections, such as (circles, parabolas, ellipse, and hyperbola), influence modern engineering design.

Influence of conic-sections in modern engineering design:

Conic sections -circle, parabola, ellipse, and hyperbola- are fundamental in engineering due to their unique geometrical properties:

Circle:

Circle are widely used in wheels, gears, bearings, pipelines, and tanks for smooth motion, load distribution, and structural strength.

Parabolas:

Parabola are essential in satellite dishes, antennas, solar panels, and bridge arches for focusing energy and distributing weight efficiently.

Ellipses:

Ellipse find applications in optical devices such as telescopes and laser systems, as well as in tunnels and arches for stability and aesthetic design.

Hyperbolas:

And signal distribution structures to optimize airflow, energy flow, or positioning accuracy.

2. How artificial intelligence helps engineers design and use these shapes more accurately and efficiently.

Role of artificial intelligence is using conic sections:

Artificial intelligence (AI) enhances engineering design by making it more accurate, efficient, and optimized:

Design optimization: AI algorithms can determine the most suitable dimensions and curvature of conic shapes to reduce material use while maintaining structural integrity.

Simulation and prediction: AI simulates real-world forces, stresses, and load conditions to predict how conic-shaped structures will perform.

Precision manufacturing: AI-powered CAD/CAM systems help engineers create and fabricate conic section with high accuracy, reducing human error.

Efficiency and Innovation: AI allows rapid testing of multiple designs virtually, enabling engineers to explore new conic configurations and select the best-performing one. Conic section are essential for modern engineering designs providing structural efficiency, stability, and functionality. AI further empowers engineers to utilize these geometric shapes accurately, efficiently, and innovatively, bridging the gap between theoretical design and practical implementation.

Parabolas:

In engineering, the parabola is used to design structures that require efficient load distribution and high strength. Parabolic shapes help transfer forces smoothly toward the supports, reducing bending stress and increasing structural stability. Due to these properties, parabolic geometry is commonly applied in bridges, roofs, and arches. Modern engineering software and AI tools use parabolic equations to create accurate, safe, and economical designs.

Fig parabola:

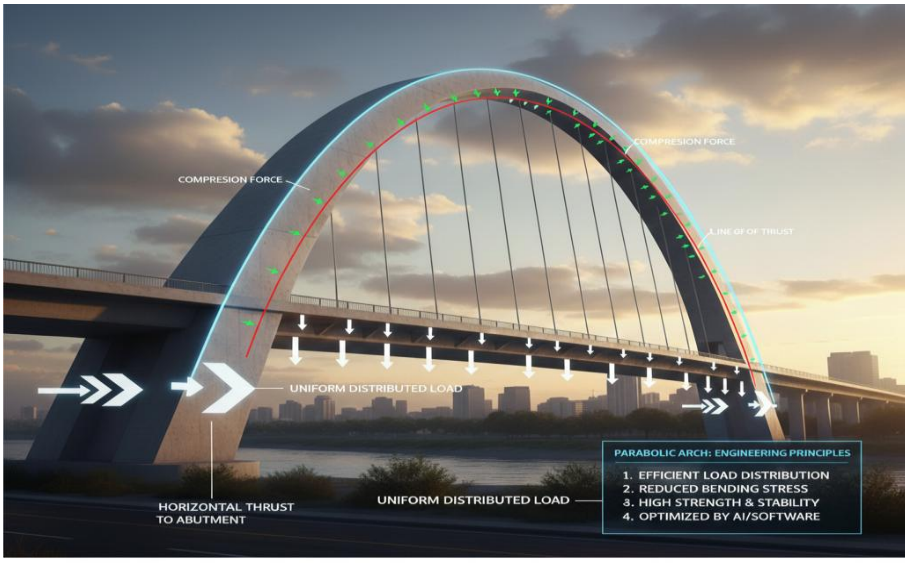
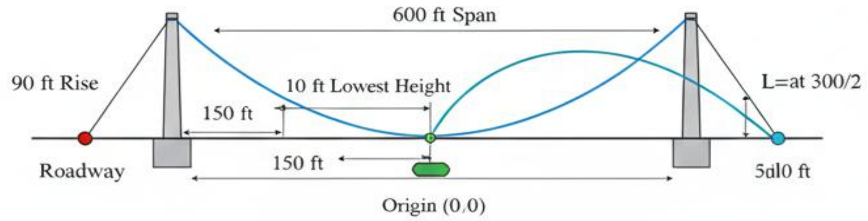


Figure 1: Engineering Mechanics of a Paraboblic Arch Bridge. This diagram illustras howis converttin & Hong axial compressial Parabolic curve, elimiinting bexctural structural stability through horizonte by modern engineering software.

Suspenion Bridg Cable Height Calculation

The cables of the suspension bridge are in the shape of paraabla. The pillars apart rise 90 feet tlıs. The lowest height of the the cable, which is 10 feet above te pillars. Whais the cables a point at boint 150 feets harizontally from the center?

Polutlem:



Solution:

Establish Coordinate System

1. Identify Known $(0, 0)$
2. Pillar Height = =500) = 90 = 90
4. Solvest Point = 1 = 10^2 $y = 300 + 90$

   $90 = 10 = a\ a(300^2 + 10$
6. Calculate the Equation fure cable

   Final Equ $a = \frac{90 - 1150^1}{80{,}9000} + 10$

   Find $y = \frac{1/1125)}{20 - 1125}(150^2 + 10$

Parabola Eq: $y = ax^2 + c$
↓
Given: (x=(300) y = 90)
↓
Final Eq: $y = 1/1120^2 + 1/1125$
↓
$y = \frac{1/1155)\ (150^2}{22{,}500(125^1} + 10$ + 10
Find y at height at $x = 50^1 + 10$ $y = 30 + 30$ ft

Conclusion: The hihe cables from ta point 150 from is 30 feet.

Problem 2

Parabola are widely used in engineering, such as in satellite dishes, bridges, water channels, because their curved shape focuses energy or directs flow efficiently. Using AI, engineers can design parabolic structures more accurately and ensure they function safely and effectively.

Ellipse: An ellipse is a curved geometric shape that is wider in one direction and narrower in the other. It is used in bridges, domes, tunnels, and satellite path because its shapes help distributes weight evenly and provides stability to structures its unique curve makes designs stronger and more efficient in carrying loads. The smooth curved design of an ellipse reduces stress points, making constructions stronger and more durable. Engineers prefer elliptical shapes in certain architectural designs and mechanical parts because it allows for efficient load handling, better aerodynamics, and optical use of space.

Fig Ellipse:

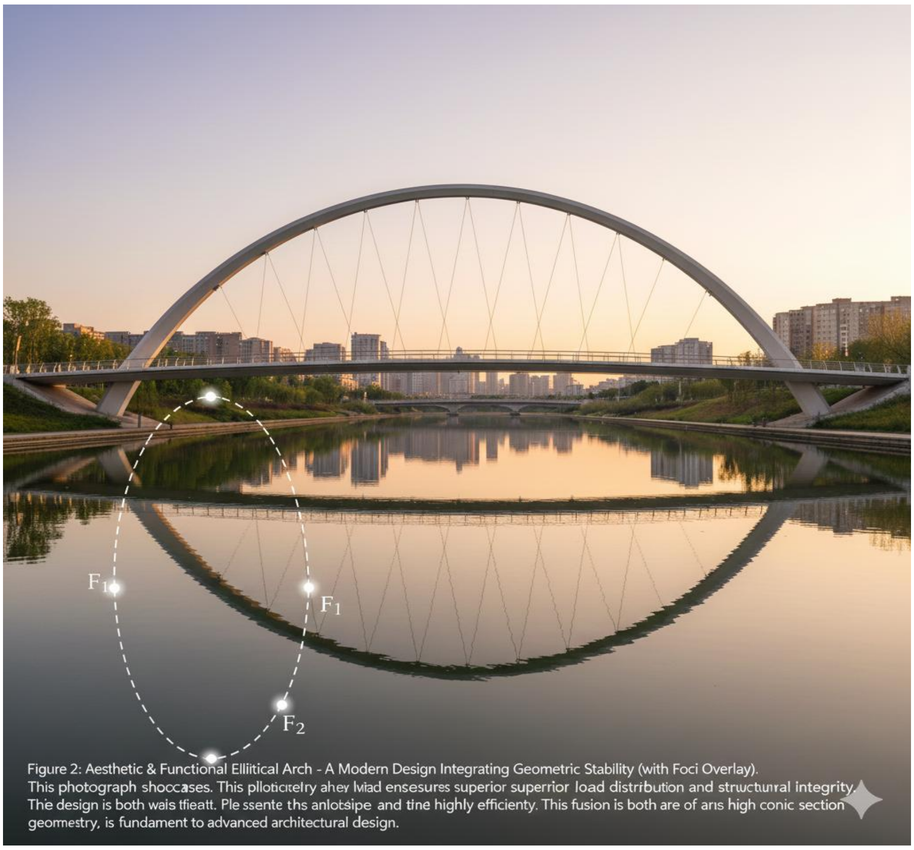


Figure 2: Aesthetic & Functional Elliitical Arch - A Modern Design Integrating Geometric Stability (with Foci Overlay). This photograph shoccases. This pllotictelry ahey lviad ensesures superior superrior load distribution and strwctunral integrity. The design is both wais tfieatt. Ple ssente ths anlotsipe and tine highly efficienty. This fusion is both are of ans high conic section geomestry, is fundament to advanced architectural design.

Problem 3.

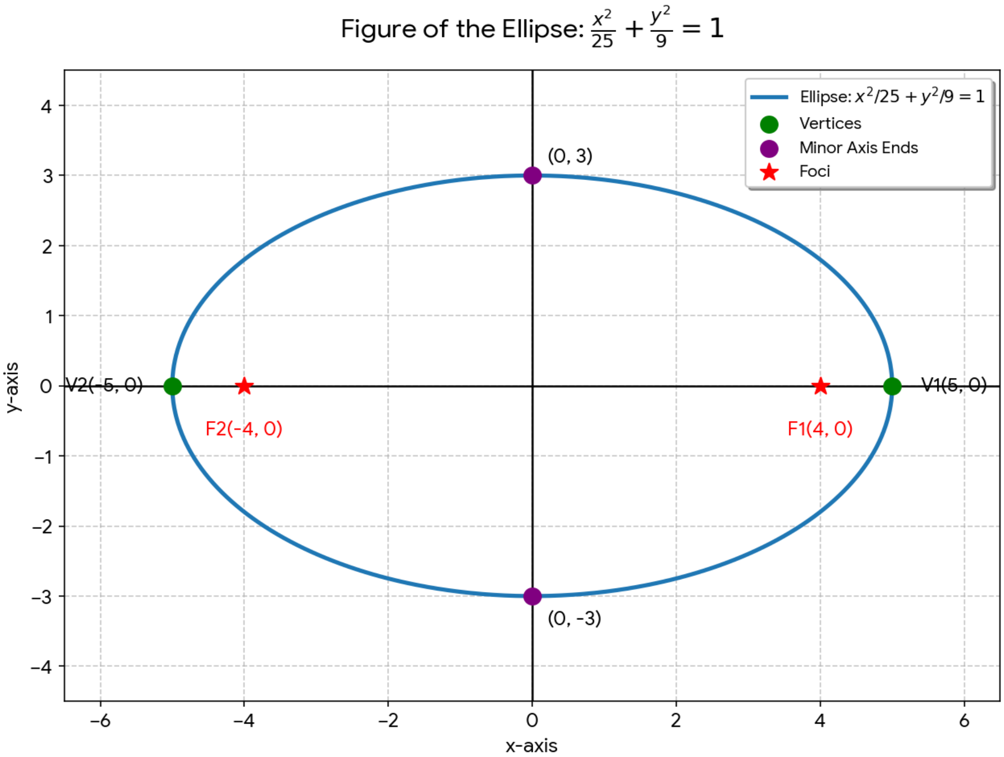
Consider an ellipse centred at the origin whose major axis lies along the x-axis and minor axis along the y-axis.

The equation of the ellipse is.

$$\frac{x^2}{25} + \frac{y^2}{9} = 1$$

Find the length of the major axis, length of the minor axis, coordinates of the foci, Eccentricity of the ellipse.

Solution:



Given ellipse:

$$\frac{x^2}{25}+\frac{y^2}{9}=1$$

Compare with standard ellipse equation:

$$\frac{x^2}{a^2}+\frac{y^2}{9}=1$$

Here,

$a^2 = 25$

a = 5 (semi-major axis)

1. Length of major axis

Major axis = 2a = 2*5=10

2. Length of minor axis

Minor axis = 2b =2*3=6

3. co-ordinates of the foci

For ellipse with major axis along x-axis:

C=$\sqrt{a^2 - b^2}$ =$\sqrt{25 - 9}$ =$\sqrt{16}$ = 4

4. Eccentricity

e = $\frac{c}{a} = \frac{4}{5}$ = 0.8

Final answer:

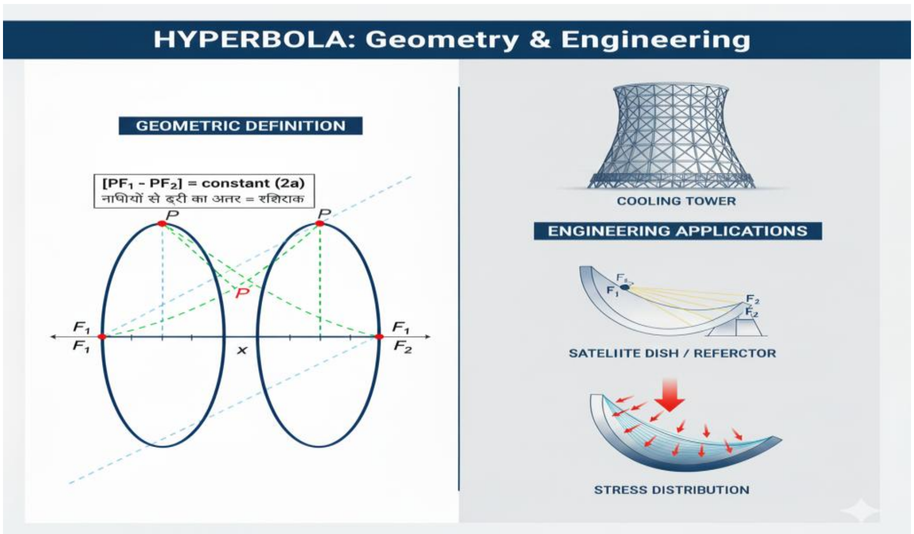
Major axis = 10 units, Minor axis = 6 units, Foci = (-4,0) and (4,0), Eccentricity e = 0.8

In conclusion, the ellipse is a unique geometric shape that provides strength and stability in engineering designs. It curved from helps distribute loads evenly and reduces stress on structures, making constructions like bridges, tunnels, and domes stronger and more durable. Smooth and continuous shape of an ellipse also improves efficiency in mechanical and electrical designs by allowing better handling of forces and optimal use of space.

Hyperbola:

A hyperbola is a geometric curve formed by two symmetrical open curves that extend infinitely in opposite directions. Its unique shape allows for efficient handling of forces and provides structural stability in certain engineering applications. Hyperbolas are commonly used in the design of cooling towers, satellite dishes, and reflective surfaces because their shape helps in directing forces, energy, or signals efficiently.

Fig: Hyperbola



A hyperbola is a curve where the distance difference to two foci is constant. The absolute difference in distance from any point p to two fixed foci F1 and F2 is constant (PF1-PF2) = 2a).

Used in cooling towers (structural strength) and satellite dishes (reflective properties).

Problem 4.

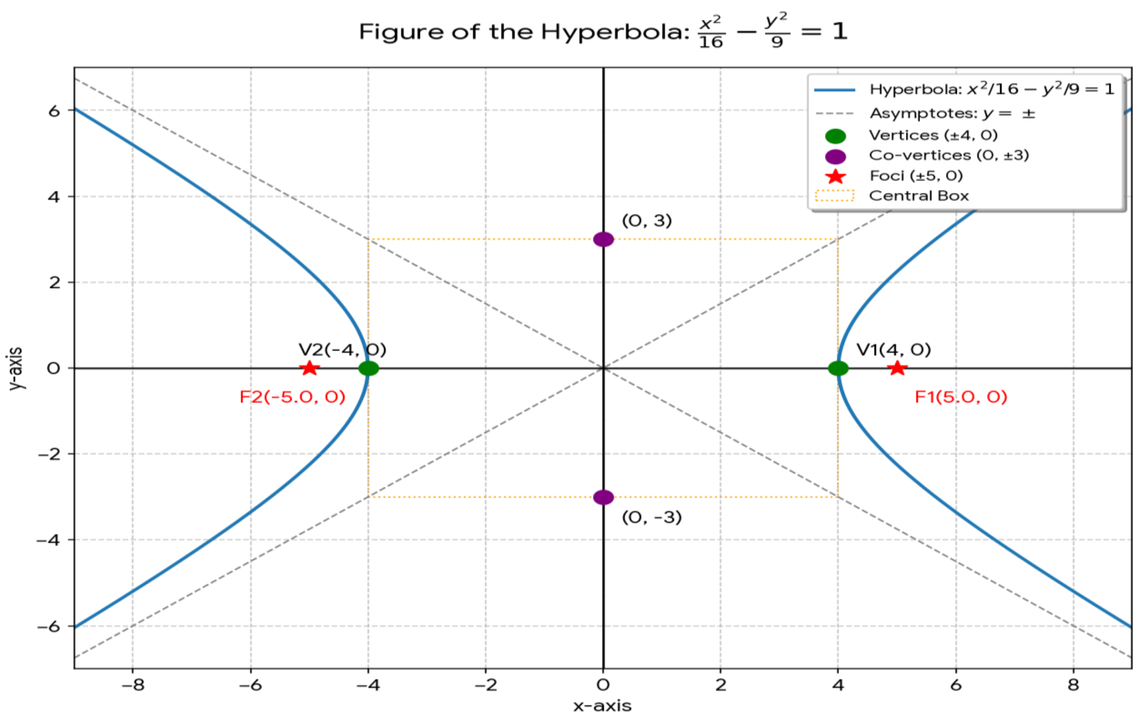
Shows a hyperbola centred at the origin O (0,0) with its transverse axis along the axis along the x-axis and conjugate axis along the y-axis.

The hyperbola is represented by the equation:

$$\frac{x^2}{16} - \frac{y^2}{9} = 1$$

Find the length of the transverse axis, the length of the conjugate axis , the co-ordinates of the foci, the eccentricity of the hyperbola.

Solution:



$$\frac{x^2}{16} - \frac{y^2}{9} = 1$$

Compare with standard hyperbola equation (transverse axis along X-axis)

$\frac{x^2}{a^2} - \frac{y^2}{b^2}=1$

Here,

$a^2 = 16$, $a = 4$ (semi- transverse axis), $b^2 = 9$, $b = 3$(semi- conjugate axis)

1. Length of transverse axis

Transverse axis =2a = 2*4 =8

2. Length of conjugate axis

Conjugate axis = 2b = 2*3 =6

3. Co-ordinates of foci

For hyperbola (transverse axis along x-axis)

$C = \sqrt{a^2 + b^2} = \sqrt{16 + 9} = \sqrt{25} = 5$

Foci lie on x-axis at:

F1(-c, 0) = (-5,0), F2(c, 0) = (5,0)

1. Eccentricity

$e = \frac{c}{a} = \frac{5}{4} = 1.25$

Final answer:

Transverse axis = 8 units, Conjugate axis =6 units, Foci = (-5,0) and (5,0), Eccentricity e = 1.25.

Hyperbola is an important conic section used in engineering and physics. Its transverse and conjugate axes define the shape, while the foci and eccentricity help in designing reflective and structural application. Numerical analysis ensures precise dimensions for practical use.

Objectives:

1. To study the impact of conic sections in civil engineering.

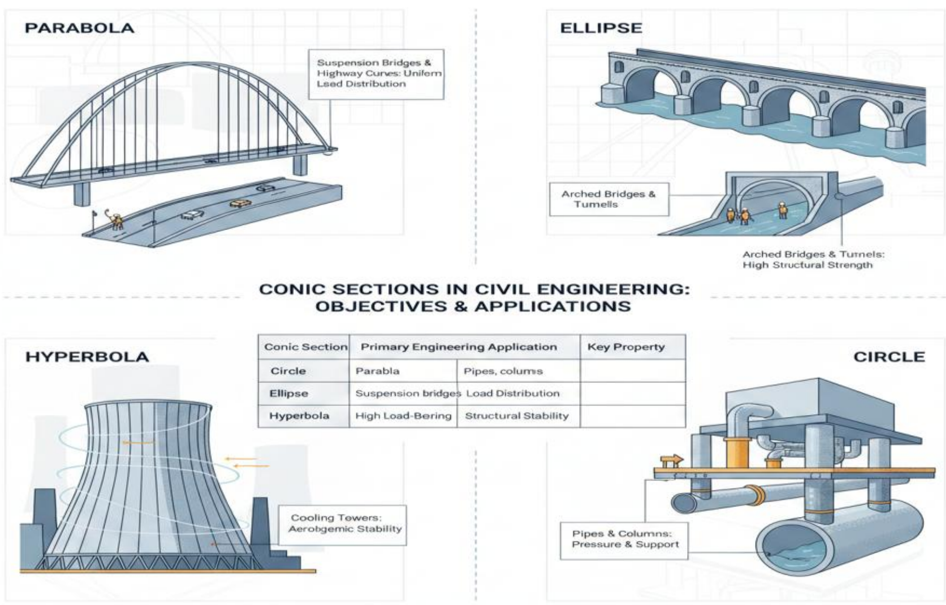
This objective focuses on understanding how conic sections like circles, parabolas, ellipses, and hyperbolas are applied in civil engineering structures. It analyses their role in improving structural stability, strength, and load distribution.

Example: parabolic arches in bridges.

Engineering Insight:

As shown in the figure, the elliptical shape allows the arch to maintain a significant height even as you move away from the centre. This geometry is preferred in civil engineering for bridge because it provides a wider "opening" for boats or water flows compared to a circular arch of the same height, while still maintaining superior structural integrity.

Figure:

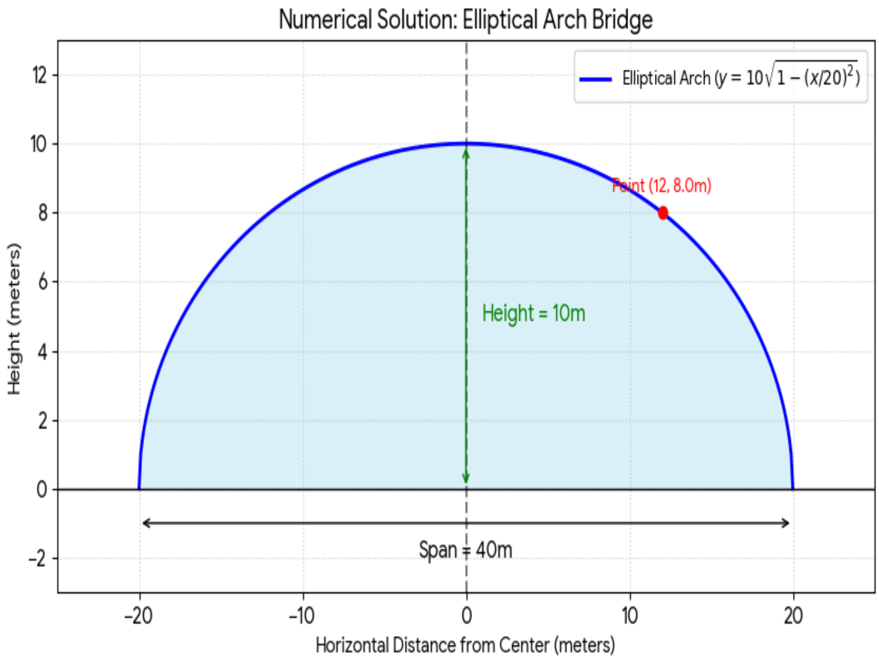


Application of conic sections in civil engineering. Parabola for suspension bridges and highway curves (uniform load distribution); ellipse for arched bridges and tunnels (high strength); hyperbola for cooling towers and load-bearing structures (stability); circle for pipes, columns, pressure vessels, and supports.

Problem 5

An engineer is a designing an elliptical arch for a stone bridge. The bridge must span a distance of 40 meters and have a maximum height of 10 meters its centre. Derive the equation of the ellipse if the centre of the span is at (0,0). Calculate the height of the arch at a point 12 meter away the centre.

Solution:



Given:

Total span = 40m, so the semi- major axis a = $\frac{40}{2}$ = 20m

Maximum height = 10m, so the semi-minor axis b = 10m

Formulate the equation the standard equation for an ellipse centered at (0,0) is .

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

Plugging in our values:

$$\frac{x^2}{20^2} + \frac{y^2}{10^2} = 1$$

Or, $\frac{x^2}{400} + \frac{y^2}{100} = 1$

Solve for the height at x=12 substitute x=12 in to the equation to find the vertical clearence y.

$$\frac{12^2}{400} + \frac{y^2}{100} = 1$$

Subtract 0.36 from both sides.

$$\frac{y^2}{100} = 0.64$$

Or, $y^2 = 64$

Or, y = $\sqrt{64}$

= 8 meters,

Final answer: the height of the arch at 12meter form the centre is 8 meters.

The study of conic sections in civil engineering demonstrates that geometric curves play a vital role in structural designs. Circles parabolas, ellipses, and hyperbolas enhance the stability, strength, and efficiency of engineering structures, enabling optimal load distribution and aesthetic appeal. Understanding their applications helps engineers design safer and more durable constructions.

2. To analyse how AI uses geometric principals to improve structural design.

This objective focuses on understanding how Artificial Intelligence applies geometric principals, including conic sections. To optimize structural design. AI can simulate different shapes, predict load distribution, and suggest the most efficient geometric forms for bridges, domes, tunnels, and other civil engineering structures. By integrating AI with geometry, engineers can achieve safer, cost- effective, and innovative designs.

Examples: Bridge arches, Domes/tunnels, Highway ramps.

a. Bridge arches: AI selects parabolic shape for the best load.

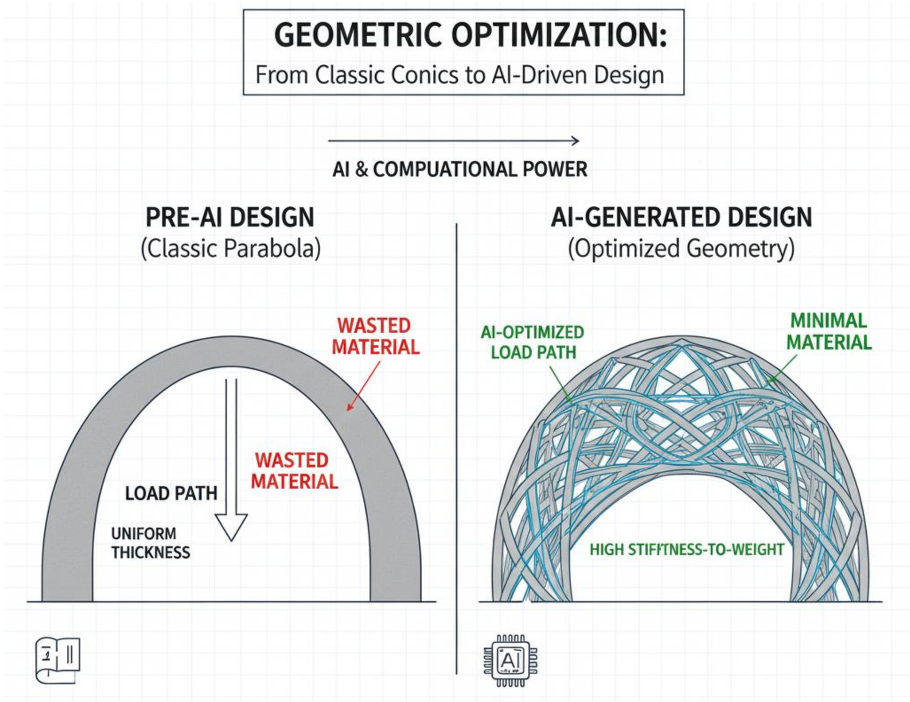
b. Domes/tunnels: AI uses elliptical shapes to maximize space and stability.

c. Highway ramps: AI applies hyperbolic curves for smooth load/vehicle transition.

Engineering insight:

AI integrates geometric principles with computational analysis to optimize structural design in civil engineering. By evaluating geometric forms such as parabolas, ellipses, and hyperbolas, AI predicts load distribution, minimizes material usage, and improves structural stability. This approach enables engineers to develop safer, more efficient, and sustainable structures.

Figure:

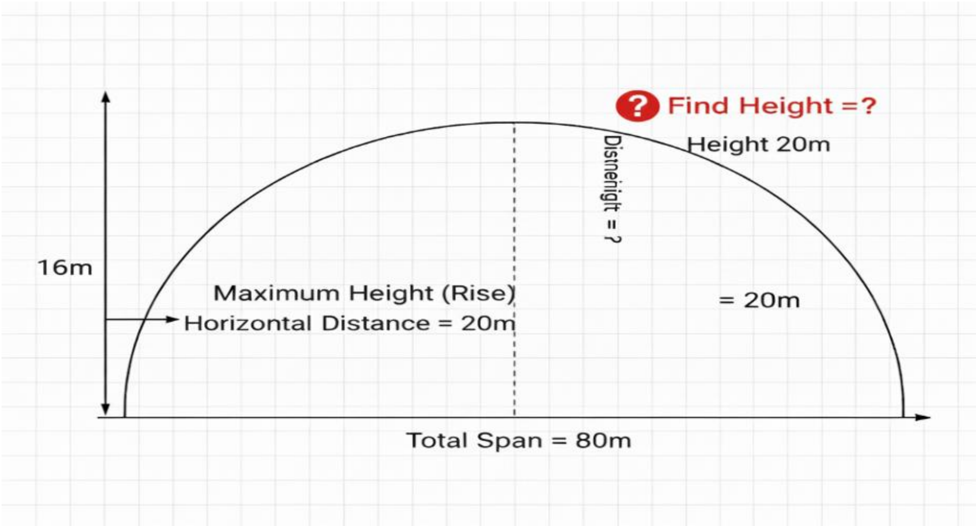


Ai- based geometric optimization in structural design showing efficient load paths and reduced material usage compared to traditional conic-based design.

Problem 6.

A civil engineer is designing a parabolic arch bridge The bridge has total span of 80 meters and the maximum height (rise) at the centre is 16 meters. Determine the mathematical equation of the parabola (placing the vertex at the origin) (0,0). Calculate the height of the arch at a horizontal distance of 20 meters form the centre.

Solution:



Given:

For a downward-opening parabola with the vertex the origin(0,0) the standard equation is.

$$y = ax^2$$

Horizontal distance (x): since the total span is 80m, the distance from the center to the edge is half of that:

$x = 40$m

Vertical distance (y): at the edge of the span $(x = 40)$, the arch has dropped from the peak to the ground. So,y = -16m (negative because it is below the vertex).

Substitute the point (40, -16) in to eqn to find a:

-16 = a $(40)^2$

-16 = a (1600)

a = $\frac{-16}{1600}$ = - 0,01.

This specific equation for these bridges is $y = -0.01x^2$

Find the height at $x = 20m$

To find the vertical drop at 20 meters from the centre substitute $x = 20$ in to our equation:

$$y = -0.01(20)^2$$

$$y = -0.01(400)$$

$$y = -4meters$$

The value $y = -4$ mean the arch is 4 meters below the peak. To find the height from the ground.

Height from ground = total rise - drop.

Height = 16m - 4m

= 12 meters.

Mathematical equation: $y = -0.01x^2$

Clearance at $20m$: $12\,meters$.

Conic sections form the foundation of structural design in civil engineering, while AI enhances their application by optimizing geometry, improving load distribution, and reducing material usage. This integration leads to safer, efficient, and sustainable engineering structures.

3. To explore real-life example in conic section in engineering projects:

Conic sections are important mathematical curves that have extensive applications in real-life engineering projects. The study of their practical applications helps to understand how theoretical mathematical concepts are transformed into efficient engineering designs. Different conic shapes contribute to improving structural stability, load distribution, motion control, and energy efficiency. Therefore, exploring real-life examples of conic-sections provides valuable insight into the role of mathematics in solving engineering problems and developing functional and reliable systems.

Example:

Parabola- satellite dishes and headlights.

Ellipse -Arches and machine components.

Hyperbola -cooling towers.

Circle -wheels and gears.

Engineering insight:

The geometric properties of conic sections allow engineers to design structures and systems that are more efficient, stable, and functional. Parabolic, elliptical, hyperbolic, and circular shapes optimize load distribution, motion, and energy use, demonstrating the direct application of mathematics in solving real-world engineering challenges.

Figure:

This figure shows four real-world examples of conic sections: parabolic cables in suspension bridges, parabolic reflectors in satellite dishes, elliptical planetary orbits around the sun, and hyperbolic trajectories (e.g., in gravity assists or cooling tower shapes).

Problem 7.

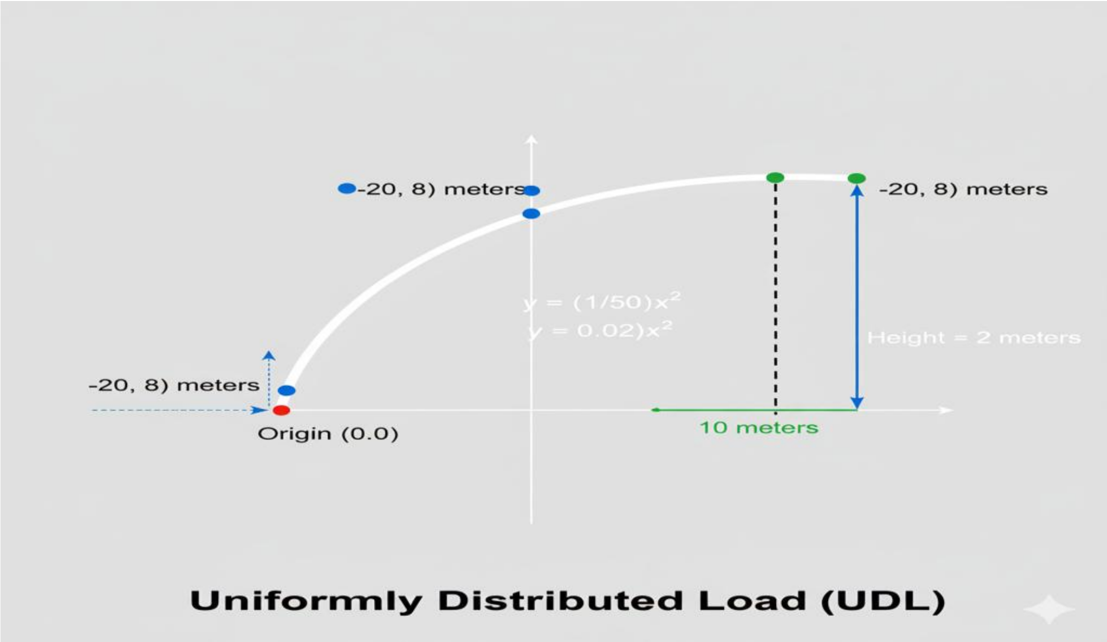
A suspension bridge cable follows a parabolic shape. The lowest point of the cable is taken as the origin. The cable passes through the point (-20,8) and (20,8), where the units are in meters.

1. Find the equation of the parabolic cable.

2. Determine the height of the cable at a horizontal distance of 10m from the centre.

3. Explain how this parabolic shape helps in uniform load distribution in bridge engineering.

Solution:



Given:

Vertex (0,0)

Support points (-20,8) and (20,8)

Query point: x=10m

Find the equation

The standard equation of a parabola with a vertex at the origin opening upwards is:

Using the known point (20,8)

$8= a\ (20)^2$

$8= 400\ a$

$a = \frac{8}{400} = 0.02$

The governing eq^n.:

$Y=0.02x^2$

Calculate height at x = 10M.

Substitute 10 for x in the governing equation.

$Y = 0.02(10)^2$

$Y = 0.02(100)$

Y = meters.

Engineering significance: uniform load distribution.

The parabolic shape is not just an aesthetic choice it is structural necessity in bridge engineering for the following reasons.

Funicular shapes for uniform loads:

A cable hanging under its own weight forms a catenary. However, when a heavy, uniform bridge deck is suspended form it, the weight of tee deck (a uniformly distributed load) pulls the cable in to parabolic shape.

Constant horizontal tension:

Mathematically, for a parabolic cable the horizontal component of the tension force is constant throughout the entire span. This makes the force distribution predictable and allows the towers to handle the load primarily through vertical compression.

Load transfer:

The parabola effectively translates the vertical weight of the traffic and the road way in to axial forces that's are transferred to the bridge main towers anchorages. This project concludes that conic sections are not only mathematical concepts but also essential tools in engineering applications. Circles, parabolas, ellipses, and hyperbolas are widely used in real-life structures such as bridges, satellite dishes, tunnels, reflectors, and mechanical systems. Their geometric properties help engineers design efficient, stable, and cost-effective structures. Thus, the study of conic sections plays a vital role in connecting mathematics with practical engineering solutions.

4. To provide visual example demonstrating the practical impact of conic section in modern civil engineering:

In modern civil engineering, conic sections are used because their shapes naturally suit real structures. For example, parabolic shapes are seen in bridges where the load is spread evenly, circular shapes are used in tunnels and water pipes to handle pressure safely, and elliptical arches are common in buildings for both strength and appearance. By observing these structures visually, it becomes clear how conic sections help engineers design stable, strong, and practical projects. This shows that conic sections fare directly connected to real-life civil engineering works, not just theory.

Example 1.

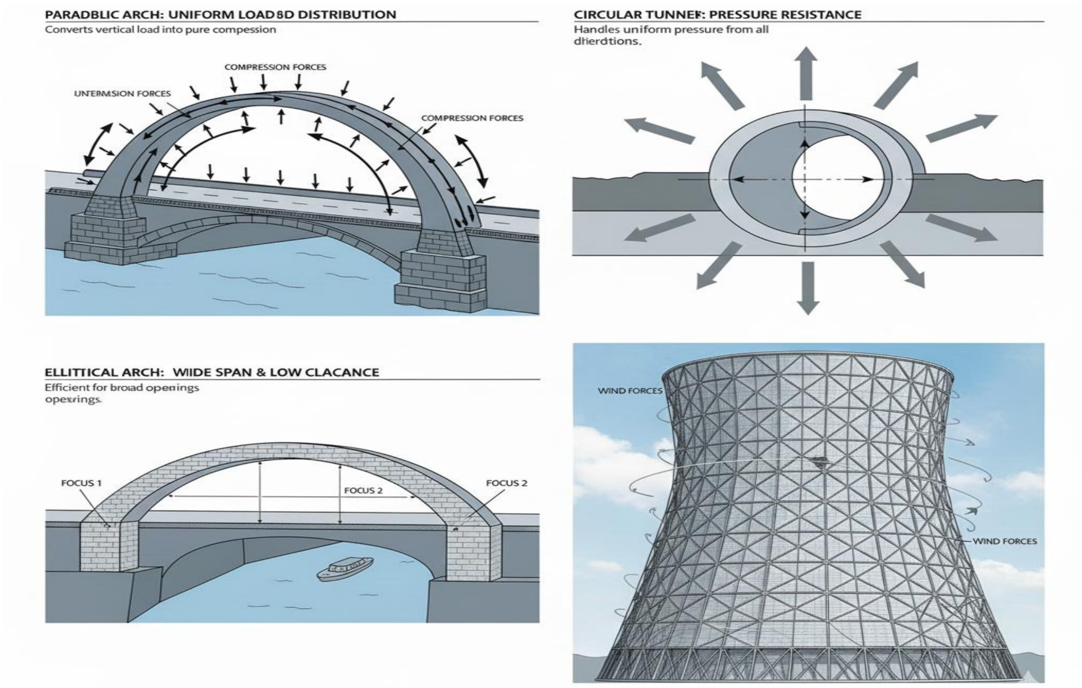
Parabolic bridge- distributes load evenly.

Circular tunnel- withstands pressure equally from all sides.

Engineering insight:

Using conic sections in civil engineering allows efficient load distribution, structural stability, and material optimization. Shapes like parabolas and circles reduce stress concentration, making bridges, tunnels, and arches safer, durable, and cost-effective. It shows how geometry directly guides practical design decisions in modern engineering.

Figure:



Conic sections turn complex physical forces in to structural stability: parabolas distribute weight, circles resist pressure ellipses bridge wide spans had hyperbolas ensure wind stability.

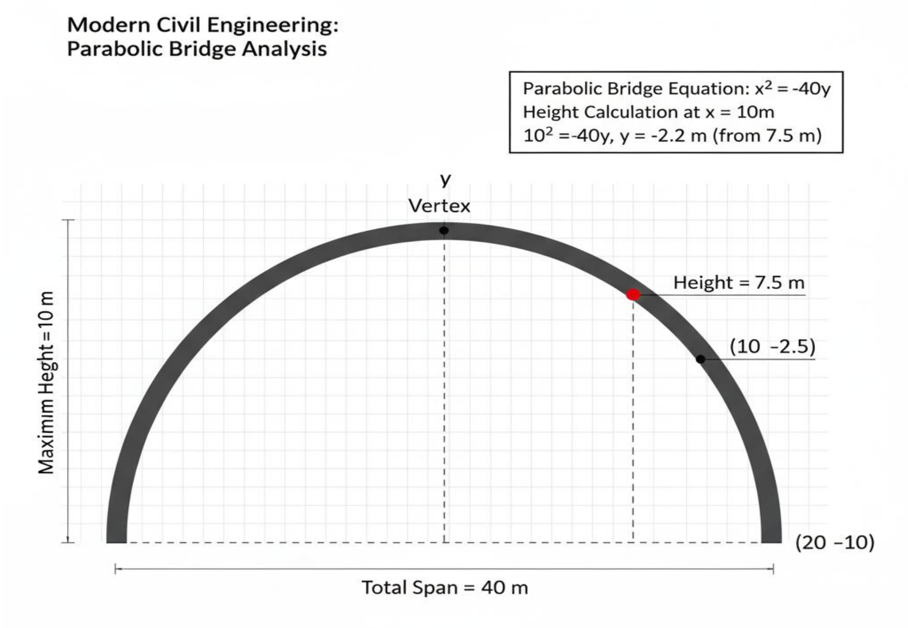
Problem 8.

A parabolic arch bridge has a apian of 40m and a maximum height of 10m at the centre.

1. Find the equation of the parabola represting the shape of the bridge.

2. Calculate the height height of the bridges at a point 10m away from the center.

Solution:



Given:

Vertex at the origin (0,0)

Total span: 40m

Maximum height: 10m

Key points: at the edge of the bridge (x = 20), so the points are (20, -10).

1. Find the equation:

The standard equation for this parabola is:

$$x^2 = 4py \text{ or } y = ax^2$$

Let, use $y = ax^2$,we plug in our point $(x = 20, y = -10)$

$$-10 = a(20)^2$$

$$a = -\frac{10}{400} = -\frac{1}{40}$$

So, the equation of bridge is:

$$y = -\frac{1}{40}x^2$$

2. Calculate height 10m from centre:

Now, we find the vertical position(y) when x=10.

$$y = -\frac{1}{40}(10)^2$$

$$y = -\frac{100}{40}$$

$$y = -2.5m$$

This means the bridge has "dipped" 2.5m down from its peak

Final height calculation: since the total height of the bridge is 10m.

$$Height = 10 - 2.5$$

$$= 7.5\text{m}$$

The height of the bridge at that point is 7.5meters.

In this topic, it is concluded that conic sections have a direct and practical impact on modern civil engineering. Shapes like parabola, ellipse, and hyperbola are widely used in the design of bridges, tunnels, arches, and tall structures to ensure strength, stability, and efficient load distribution. Through numerical analysis, it becomes clear that theses mathematical curves help engineers reduce material usage while increasing safety and durability. Therefore, conic sections are essential mathematical tools that support effective and economical civil engineering designs.

5. To examine real-life application of conic section

In bridges, arches, tunnels, roofs, and towers.

Conic sections, such as parabolas, ellipses, and hyperbolas, are not just mathematical concepts-they have practical importance in everyday life and civil engineering. When we cross a bridge or walk through a tunnel, the shapes we see are often take parabolic curves are used ib bridges and suspension cables because they distribute loads evenly, making the structure string and safe. Arches often take parabolic or elliptical shapes, which efficiently support heavy weights. Elliptical tunnels can withstand the pressure from surrounding soil, while hyperbolic towers provide high stability with less material. In this way, conic sections help are practical and reliable for human use.

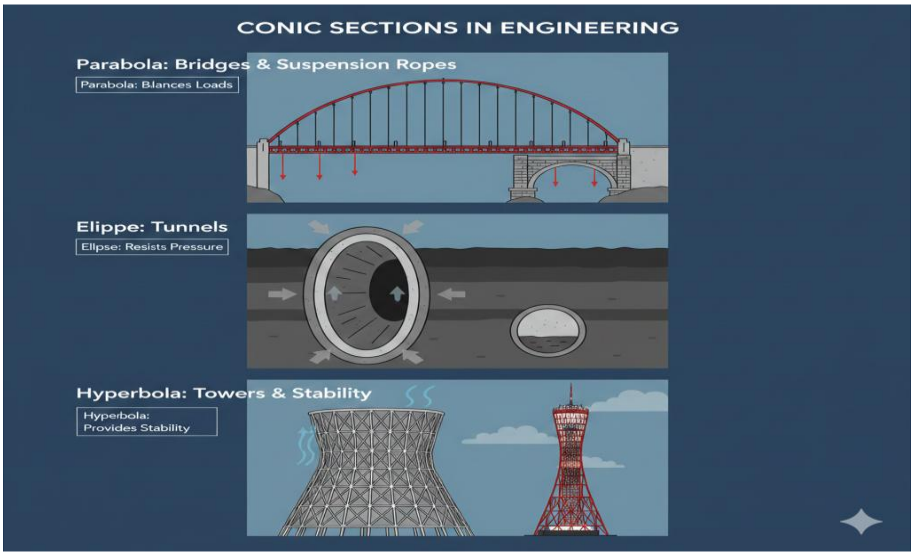
Example: Bridge (parabolic shape):

The Akashi Kaiko bridge in Japan uses parabolic cables. The parabolic curve helps the bridge carry heavy load evenly and reduces stress on the structure, making it strong and safe for vehicles and pedestrians.

Engineering insight:

Conic section allows engineers to design structures that carry stability. For example, parabolic bridges and cable distribute weight evenly, elliptical tunnels resist soil pressure, and hyperbolic towers achieve high strength with minimal material. This shows how mathematical curves directly improves safety, durability, and cost-effectiveness in modern civil engineering.

Figure:

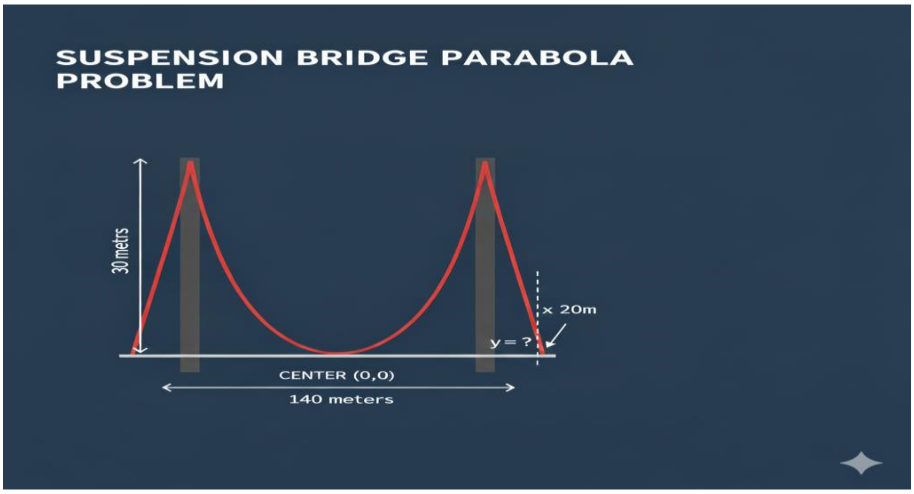


Role of conic section in civil engineering structures top: parabolic shape in arch bridges for load balancing. Middle: Elliptical cross- section in tunnels for pressure resistance. Bottom: Hyperbolic form in cooling towers and radio towers for stability.

Problem 9.

A suspension bridge has a span of 140meters. The two towers supporting the cable are 30meters high. The cable touches the road surface exactly at the centre of the bridges. Find the height of the cable at a point 20meters always from the centre.

Solution:



Given:

Vertex:(0,0)

Span: 140m

X=70m

Tower height: 30m. this gives us a point on the parabola at (70,30).

Determine the equation.

The standard equation for a parabola opening upwards with a vertex at (0, 0) is:

$$x^2 = 4ay$$

Alternating it written as:

$$y = kx^2$$

To find the value of k, substitute the towers co-ordinates (70,30):

$$30 = k(70)^2$$

$$30 = 4900k$$

$$k = \frac{30}{4900} = \frac{3}{490}$$

so, the equation of the bridge cable is:

$$y = \frac{3}{490}x^2$$

Calculate the Height at 20m aways.

Now, we find the height (y) when the horizontal distance from the center is x=20.

$$y = \frac{3}{490}(20)^2$$

$$y = \frac{3}{490}(400)$$

$$y = \frac{1200}{490}$$

$$y = 2.4489 meter.$$

The height of the cable at a point 20 meters aways from the centre is approximately 2.45 meters.

Conic sections have a significant practical role in civil engineering, as their shapes are used in bridges, arches, tunnels, ropes, and towers to achieve strength and stability. Parabolic, elliptical, and hyperbolic forms help distribute loads efficiently, resist external pressure, and reduce material usage. Therefore, conic sections are essential mathematical tools that enable engineers to design safe, durable, and economical structures for real-life applications.

Conclusion

Conic sections- circles, ellipse, parabolas, and hyperbolas-play a vital role in both classical geometry and modern engineering. Their unique shapes allow engineers to design structures, optimize load distribution, and create precise models that improve the efficiency and reliability of machines and systems. In addition, the integration of conic section principals with artificial intelligence and geometric modelling enables innovation. Overall, the study highlights how classical geometric concepts continue to influence contemporary engineering solutions, bridging the gap between mathematical theory and technological advancement.

References

Bhattarai, S., et al. (2025). Advances of AI in Mathematics: Overview of Operation Management. *Kuwait Journal of Engineering Research, 3*(1), 12–26.

Das, P. K., Sahani, S. K., & Mahto, S. K. (2024). Significance of Conic Section in Daily Life and Real-Life Questions Related to It in Different Sectors. *Journal Pendidikan Mathematica, 1*(4), 14.

Khan, S., & Kumar, A. (2019). Mathematical Modeling of Irregular Spaces for Modular Furniture Design. *International Journal of Engineering Research & Technology, 8*(7), 432–438.

Mishra, R., & Sahani, S. K. (2024). Modern Designs Using Parabolic Curves as a New Paradigm for Sophisticated Architecture. *Asian Journal of Science, Technology, Engineering, and Art, 2*(5), 772–783.

Pandey, A., Mandal, D. N., & Sahani, S. K. (2025). Parabolic Applications in Suspension Bridge Design: Mathematical Modeling, Structural Analysis, and Computational Verification. *Explodium, 46*(2), 1313–1335.

Pandey, P., Karn, A., Mandal, D. N., & Sahani, S. K. (2025). Geometric Optimization of Under-Staircase Storage Using Trigonometric and Coordinate Methods: A Mathematical Framework for Efficient Space Utilization in Urban Dwelling. 29(1), 613–630.

Sahani, S. K. (2021). Business Demand Forecasting Using Numerical Interpolation and Curve Fitting. *The International Journal of Multiphysics, 15*(4), 482–492.

Sahani, S. K., et al. (2019a). A Case Study on Analytic Geometry and Its Applications in Real Life. *International Journal of Mechanical Engineering, 4*(1), 151–163.

Sahani, S. K., et al. (2019b). A Case Study on Analytic Geometry and Its Applications in Real Life. *International Journal of Mechanical Engineering, 4*(1), 151–163.

Sahani, S. K., et al. (2023). Constructing a Precise Method to Control Non-Linear Systems Employing Special Functions and Machine Learning. *Communications on Applied Nonlinear Analysis, 30*(2), 1–14.

Sahani, S. K., et al. (2025). Case Study on Mechanical and Operational Behavior in Steel Production: Performance and Process Behavior in Steel Manufacturing Plant. *Reports in Mechanical Engineering, 6*(1), 180–197.

Sahani, S. K., & Prasad, K. S. (2023). Relative Strength of Conic Section. *The Mathematics Education, LVII*(1).

Sahani, S. K., & Sah, B. K. (2024). Integrating Neural Networks with Numerical Methods for Solving Nonlinear Differential Equations. *Computer Fraud and Security, 2024*(1), 25–37.

Shah, P., & Sahani, S. K. (2025). Practical Use of Derivatives in Different Engineering Fields. *Mikailalsys Journal of Advanced Engineering International, 3*(1), 1–20.

Shrestha, M., & Gurung, B. (2021). Urban Housing and Space Efficiency in Kathmandu Valley. *Nepal Journal of Science and Technology, 22*(1), 112–125.

Terzidis, K. (2006). *Algorithmic Architecture*. Routledge.

Thakur, S., Mandal, D. N., & Sahani, S. K. (2025). Navigating the Skies: An Application of Coordinate Geometry in Aerial Navigation and Flight Path Analysis. 3(1), 30–47.

UN-Habitat. (2012). *Going Green: A Handbook of Sustainable Housing Practices in Developing Countries*. United Nations Human Settlements Programme.

Weygant, R. S. (2011). *CAD and BIM for Interior Design*. Fairchild Books.

Zimmerman, A., & Martin, M. (2001). *Home Storage Solutions*. Creative Homeowner.