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| **Project Title** | Suspension bridge | | |
| **Project Code** | **MATH203i-01** | **Course Name** | **Differential Equations** |
| **Professor** | **Ethar Ahmed Abdelsalam** | | |
| **TA** | **Fatma Helal Mabrouk** | **Mentor Name** | **Adham Haggag/Ahmed Nabil** |
| **Team Name** | **1% of the 1%** | | |
| **Team Members** | **Youssef Hassan** | **Eslam Nasr** | **Abdallah Khaled** |
| **Abdallah Khaled** | **Michael Wagdy** | **Philopater Ayman** |
| **Problem Summary** | Suspension bridges are a type of bridge that are supported by cables suspended from tall towers. These bridges are known for their elegant design and long span, but they also present unique engineering challenges due to their reliance on cables to support the weight of the bridge and its deck. One such challenge was demonstrated by the collapse of the Tacoma Narrows Bridge in 1940, which was caused by a phenomenon known as "aeroelastic flutter." This is a type of vibration that occurs when the bridge deck starts to oscillate in the wind. The oscillations became stronger and stronger, eventually causing the bridge to collapse.[1][2] | | |
| **Methodology** | Construction of the suspension bridge is conducted in the following order:   1. The bridge deck is created last, followed by the main cables and towers. 2. The concrete tower base is built following the excavation. 3. The main cables are strung between the towers and secured at the ends once the anchorages are finished. 4. The construction of the deck begins when the suspenders are connected.   The differential equation of a general suspension bridge    In this equation, x represents the displacement of the bridge deck, t represents time, m is the mass of the bridge deck, k is the stiffness of the bridge's cables and other structural elements, c is the damping coefficient, and F(t) is the external force acting on the bridge deck at time t. The second derivative of x with respect to t [x``(t)] represents the acceleration of the bridge deck, and the first derivative of x with respect to t [x`(t)] represents the velocity of the bridge deck.  mass \* acceleration + stiffness \* displacement + damping \* velocity = external force. [3][4] | | |
| **Achievements and Skills Gained** | 1. The collapse of the Tacoma Narrows Bridge was a significant event that led to changes in the way suspension bridges were designed and engineered. 2. Engineers gained valuable skills and knowledge in the use of differential equations and other analytical tools to predict the behavior of suspension bridges under various loads and forces. 3. This knowledge has been applied in the design and construction of many safe and stable suspension bridges around the world. | | |

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| **Main Results** | The output of this code is a plot of the displacement x(t) of the system as a function of time. |
| **Discussion and Conclusion** | Suspension bridges are supported by cables anchored to towers and suspended above the roadway. Their motion can be modeled using a second-order differential equation, which can be used to simulate the bridge's response to various loads and identify potential design weaknesses. This information can help improve the safety and efficiency of suspension bridges, as demonstrated by the collapse of the Tacoma Narrows Bridge and the subsequent development of new design standards. |
| **References** | [1] <https://www.britannica.com/technology/suspension-bridge>  [2] <http://unionchainbridge.org/bridge-story/hsb/>  [3] <https://www.hindawi.com/journals/mpe/2010/805195/>  [4] <http://homepages.math.slu.cz/KarelHasik/Edwards_Penney%20-%20Elementary%20Differential%20Equations.pdf> |
| **Future Work and Suggestions** | Future Work:   * The current model can be extended to include more realistic factors such as wind forces, variations in temperature, and human movement on the bridge. * The model can be used to optimize the design of new bridges by simulating unique design configurations and comparing their dynamic responses.   Suggestions:   * It may be useful to incorporate machine learning techniques to improve the accuracy of the model, such as using neural networks to approximate the differential equations. |
| **Group Photo** |  |