Project report of Advanced Mechanics of Solids

Deflection Calculator

Submitted to

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Index

Contents **Page No.**

Abstract

The rise of computers has become our unfaultable support and not only has it changed but immensely simplified the way we look at physical situations. A way to interact with the computer is through the various computer languages.

In this project, **Python** computer language is used to find the deflection equation.

In this project, we have simulated the deflection of a standard specimen beam using the Euler-Bernoulli beam equation. The application is made using various Python libraries like *Numpy*, *Sympy*, *pandas* etc.

The application built using *kivyMD* shows a window to a user from where the user can select desired predefined boundary condition and loads. In the end, the application will represent another window of the elastic curve which is created using *tkinter*.

Aim

In engineering, deflection is the degree to which a part of a structural element is displaced under a load. It may refer to an angle or a distance.

Concept of deflection of beam is widely used in the context of building construction. Architects and engineers select materials for various applications.

The project aims to help all Mechanical engineers and civil engineers, design Materials under specific conditions and help a Material scientist select the properties of Materials.

Mathematics behind the model

Euler–Bernoulli beam theory (also known as engineer's beam theory or classical beam theory) is a simplification of the linear theory of elasticity which provides a means of calculating the load-carrying and deflection characteristics of beams.

It covers the case corresponding to small deflections of a beam that is subjected to lateral loads only.

By ignoring the effects of shear deformation and rotatory inertia, it is thus a special case of Timoshenko beam theory.

It was first enunciated circa 1750, but was not applied on a large scale until the development of the Eiffel Tower and the Ferris wheel in the late 19th century.

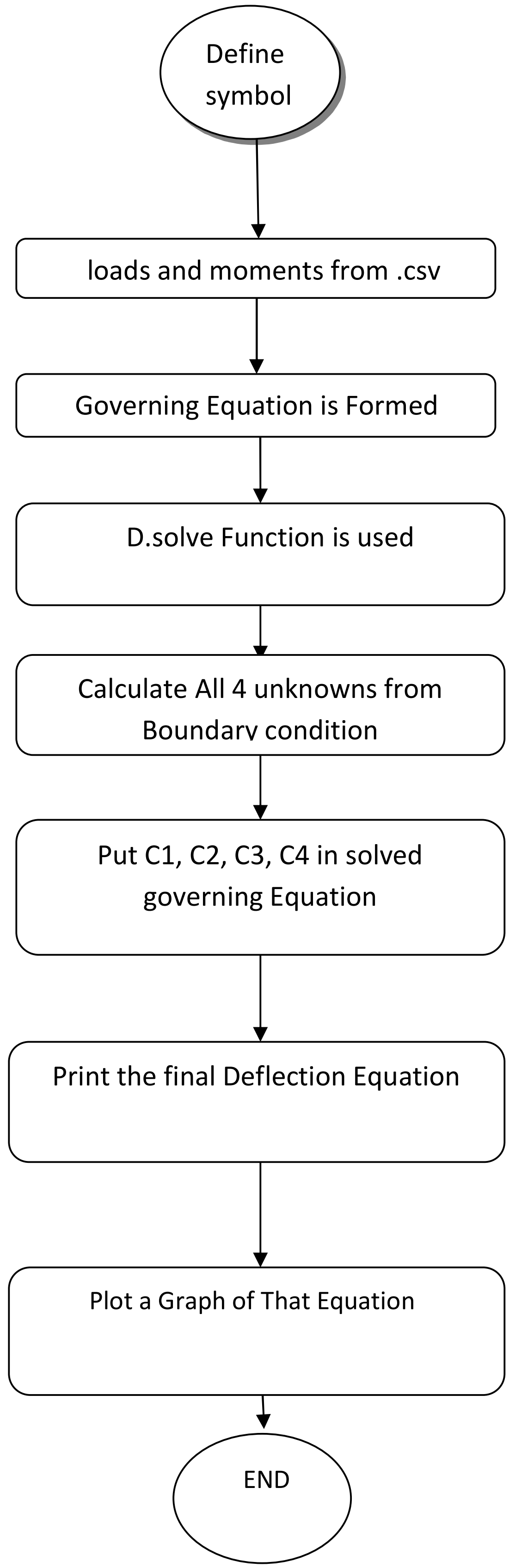
Assumption of Euler Bernoulli beam theory

- Stress at a cross-section varies linearly in the direction of bending and is zero at the centroid of every cross section.
- The bending moment at a particular cross section varies linearly with the second derivative of the deflected shape at that location.
- The material of the beam is isotropic.
- The applied load is orthogonal to the beam's neutral axis and acts in a unique plane.
- Plane Section Remains Plane after Bending.

Equations of Euler Bernoulli theory:

- $\frac{\partial^2}{\partial x^2}\left(EI\,\frac{\partial^2 w}{\partial x^2}\right) = q(x) + P\delta(x - l)$
- $\left(EI\,\frac{\partial^2 w}{\partial x^2}\right) = M(x)$

Backend Algorithm:

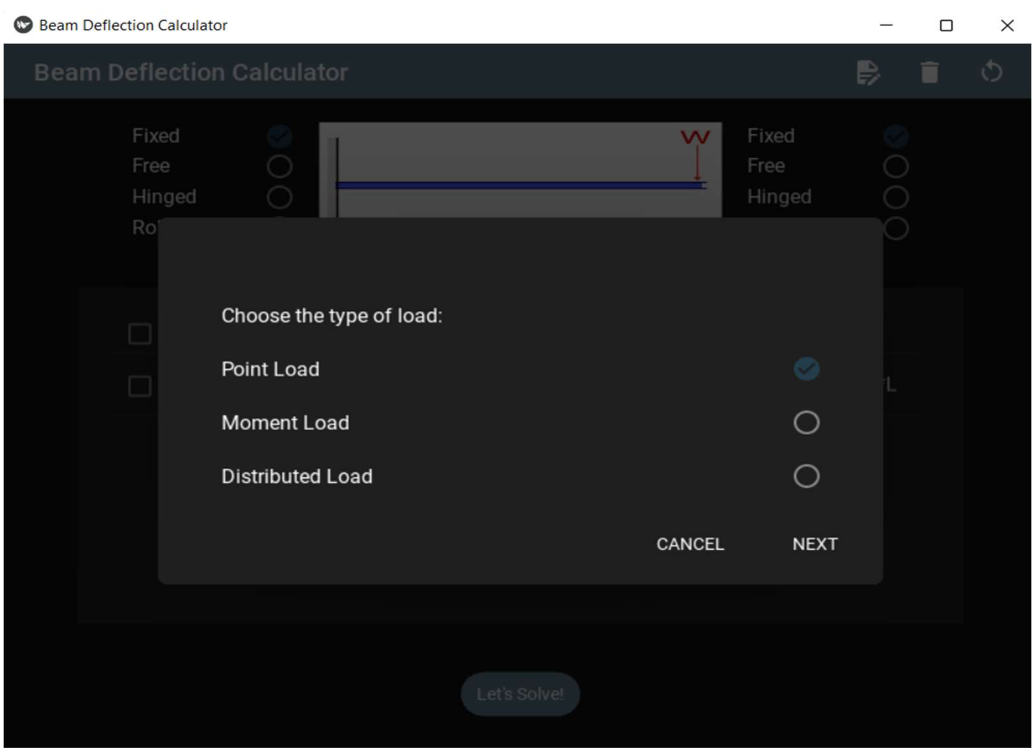


Predefined boundary Conditions:

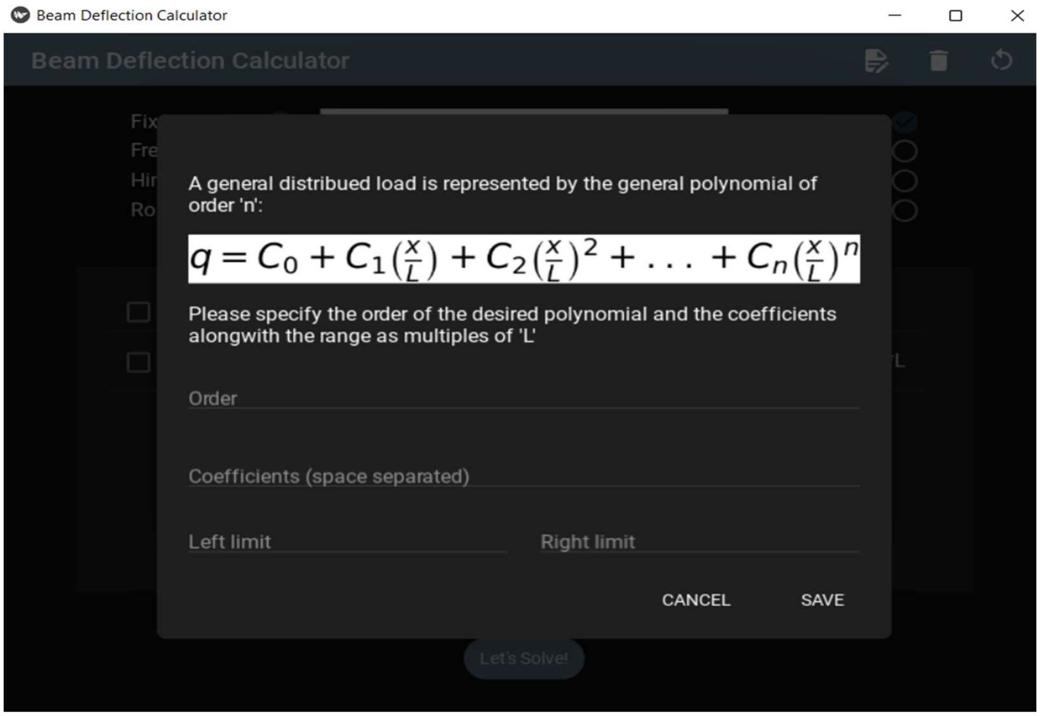
	Boundary condition 1	**Boundary condition 2**
Fixed	Slope=0	Vertical deflection=0
Free	Moment=0	Shear force=0
Hinged	Moment=0	Vertical deflection=0
Roller	Moment=0	Vertical deflection=0

Graphic User interface

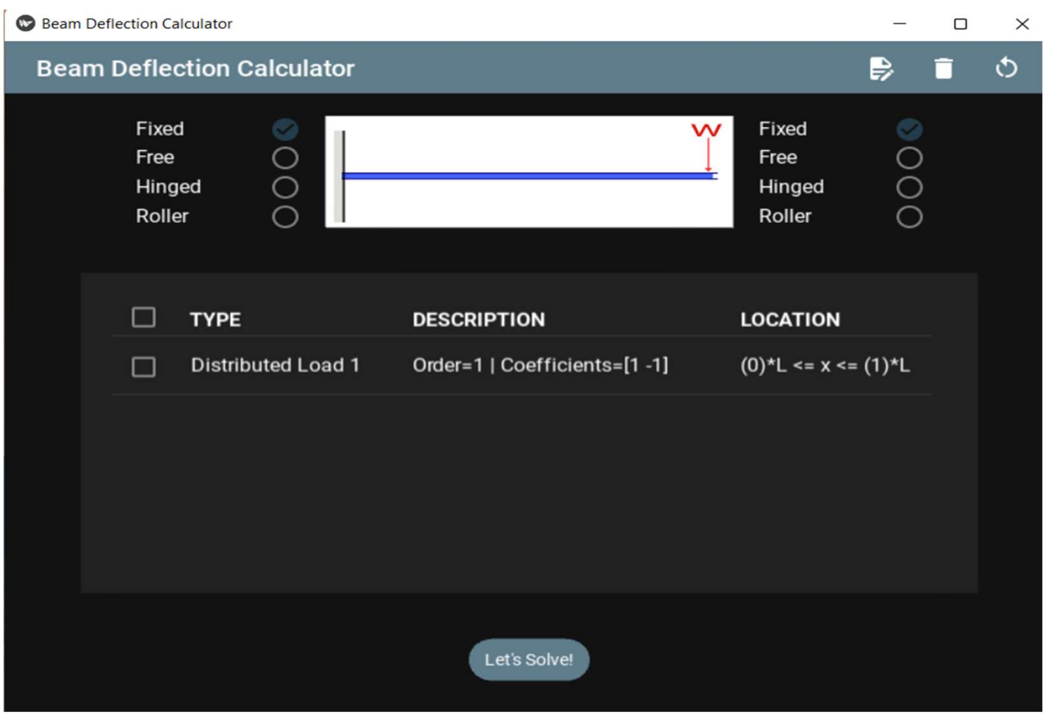
1. First the type of load is chosen



2. Value of Load is asked from the user

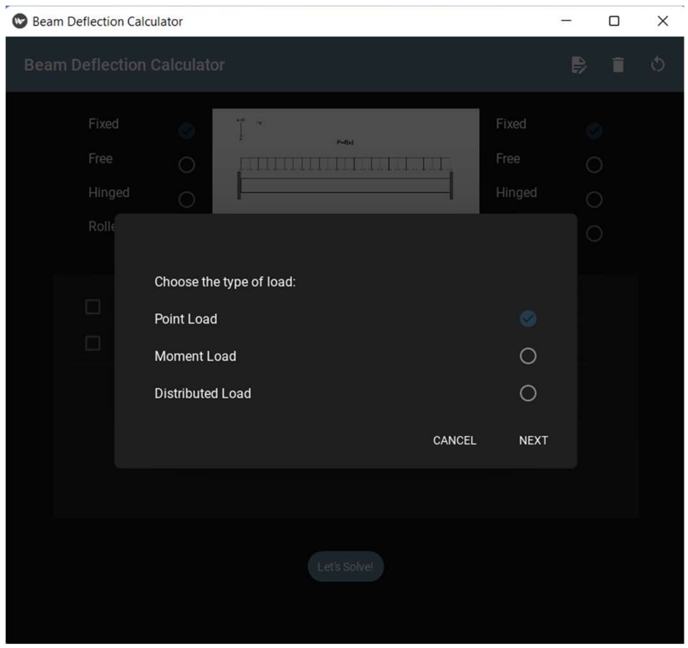


3. Type of boundary condition is asked from the user

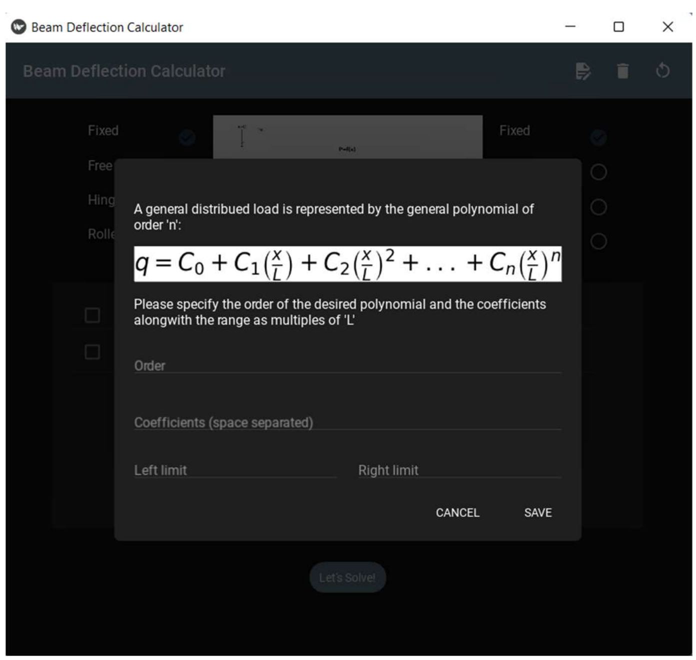


Test Case:

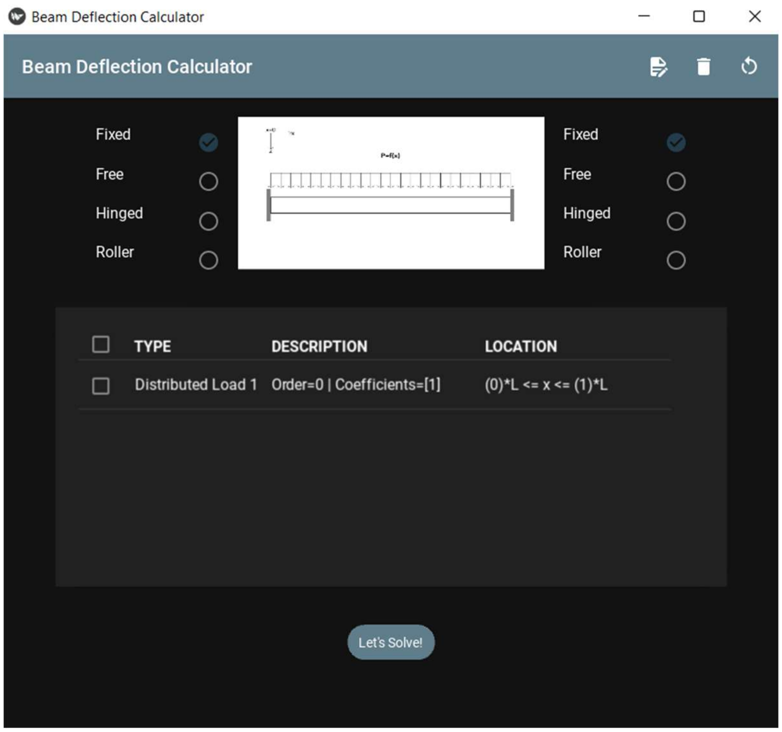
A test case was run to see whether the program could solve a basic case giving the deflection not only as a function of the spatial variable *x* but also at a certain value of *x* if required.



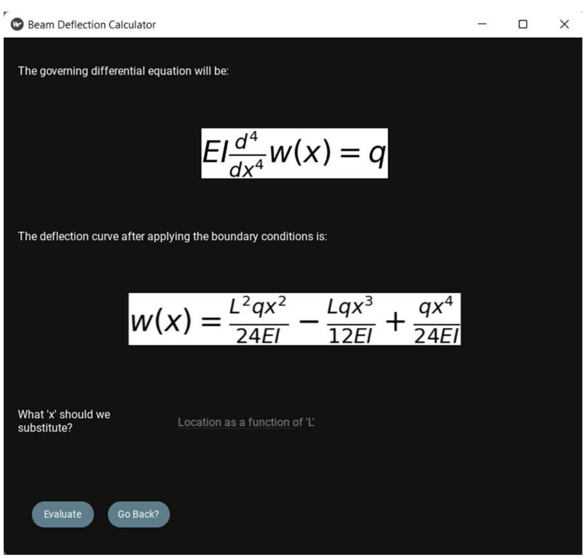
Defining Loads at various locations

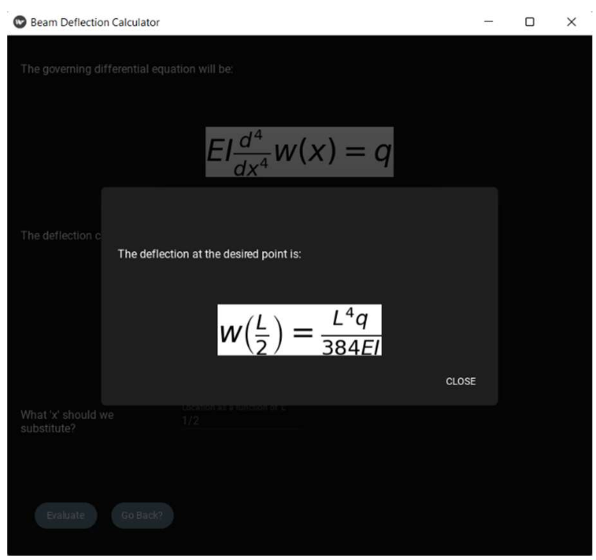


Defining a distributed load



Distributed load introduced





Deflection as function of *x* and at a specific location

Role of group members:

Koustav Chakraborty (group leader)

- Suggestion of the project idea and
- Creation of the GUI using KivyMD
- Debugging and Completion of backend code
- Coordination and assembly of the contributions of other members.

Singhmar Harbaksh Singh

- Combining the mechanics of beam deflection with the *Sympy*
- Involved in the backend programming
- Worked on the project report.

Papai Biswas

- Combining the mechanics of beam deflection with the *Sympy*
- Involved in the backend programming
- Worked on the project report.

Chandranibh Brahma

- For better visualization, *tkinter* library was used to create the diagrams based on the inputs obtained from the user
- Worked on the project report

References

- https://www.youtube.com/watch?v=yQSEXcf6s2I&list=PLCC34OHNcOtoC6GglhF3ncJ5rLwQrLGnV
- https://www.youtube.com/watch?v=yQSEXcf6s2I&list=PLCC34OHNcOtoC6GglhF3ncJ5rLwQrLGnV