Problem Statement and Goals
BeamBending

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Table 1: Revision History

Date	Developer(s)	Change
Jan. 20, 2023	Jason	Template created & committed to git.
Jan. 20, 2023	Jason	Template filled in.

1 Problem Statement

Beams safely support many constructions under load. Everything from bridges and skyscrapers to commercial and residential properties use beams to safely carry load by distributing the stress into their foundations and the ground [1]. Beams are flat, horizontal structural elements. They bear load perpendicular to their horizon [1].

Typically, inhabitants of residential constructions expect their floors to be flat, balanced, and rigidly unmoving, or else they might feel uncomfortable in their space. As such, beams must be rigidly fixed in place and be capable of transferring all imposed loads down to the foundations of the buildings and the ground. However, for other applications, such as bridges and beds of machine tools, beams are free, within reason, to move horizontally [2]. *Simply supported* beams are one kind of beams that are commonly found in these other applications.

Simply supported beams use only two supports: a *pinned* support and a *roller* support [3]. The pinned support is fixed and unmoving, while the roller support allows the beam to expand or contract axially [3]. To understand how simply supported beams handle uniformly distributed loads, we aim to approximate the curve of deflection of a beam under various conditions.

1.1 Problem

Under simplified assumptions (i.e., Euler-Bernoulli beam theory [4]), to understand how various simply supported beams can safely carry uniformly dis-

tributed loads, engineers must understand how beams deflect and how the ends react.

1.2 Inputs and Outputs

As the scope of the work is relatively limited, the inputs and outputs are also relatively limited. The inputs and outputs are as follows, following the essential aspects of [3]:

1.2.1 Inputs

1. Beam structural properties:
   (a) length,
   (b) material modulus of elasticity (Young's modulus), and
   (c) moment of inertia.
2. Magnitude of uniformly imposed force/load.

1.2.2 Outputs

1. At the supports, respectively:
   (a) force reactions, and
   (b) angle of rotation.
2. Related to the beam:
   (a) maximum deflection distance,
   (b) bending moment, and
   (c) transverse shear force.

1.3 Stakeholders

As this work is a task of CAS 741, the stakeholders of this case study includes Dr. Spencer Smith (who will be reviewing the work), myself (Jason Balaci, who will be taking authorship of the work and whose grade is dependent on this work), and peers in CAS 741 (notably, reviewers). Additionally, as this work is expected to be performed using, and contribute to, Drasil [5], Dr. Jacques Carette is another stakeholder in the final product and contributions to Drasil. Notably, as a colleague in CAS 741 and in the Drasil Research Team, Sam Crawford is also a stakeholder in this work. Finally, as this work will additionally become a case study under Drasil, the greater community related to Drasil is also a stakeholder.

1.4 Environment

As this work will be built using Drasil, it will be made in Haskell according to the Haskell2010 language specification [6], and it is limited to producing the software artifacts which Drasil is able to generate. Since Drasil already covers generating software artifacts for general-purpose programming languages that compile and run on major operating systems and Central Processing Unit (CPU) architectures, usability of the final software artifacts should not be an issue to the majority of users. However, should foreign hardware or software be desired as an environment, an extension should be built in Drasil to allow for generating suitable software artifacts.

2 Goals

This primary purpose of this work is to be a learning experience for myself, Jason Balaci, about the development of Software Requirements Specifications (SRS) documents and Scientific Computing Software (SCS). The secondary purpose of this work is to create a new case study in Drasil whilst extending Drasil's captured mathematical knowledge to include boundary value problems.

The tangible goals of this case study are as follows:

1. to extend Drasil's mathematical knowledge (at least to include boundary value problems) and better understand it's current limitations, and
2. to *generate* a software artifact that conforms to the requirements as described by a well-formed SRS document abstraction. The SRS document abstraction will follow the needs of sufficiently describing the "problem" as described earlier in subsection 1.1.

3 Stretch Goals

If time permits, there are also additional goals of this work, both related to Drasil and the specific case study, with some overlap.

1. Related to Drasil:
   (a) extend Drasil to generating GNU Octave or Julia code,
   (b) create a guided, interactive tutorial on working with Drasil (as discussed in [7]),
   (c) understanding the needs of building and manipulating "chunks" [5] in Drasil, in the context of my doctorate work (with particular focus on [8]),
   (d) capture the idea of "contexts" to theories for Drasil to be able to specialize/refine contextual quantities, theories, and other chunks to particular contexts, and

(e) to become better acquainted with the chunk structure of Drasil, potentially making contributions where applicable.

2. Related to the case study:

   (a) build a family of case studies related to simply-supported beams for *various kinds of loads*,

   (b) build a family of case studies related to *various types of beams* for *various kinds of loads*,

   (c) generate a visual diagram of the beam deflection at loading, and finally,

   (d) to solve the same problem with a system of linear equations instead of the boundary-value problem formation.

References

[1] Noah Moscovitch. *What are beams & columns in structures?* 2020-12. URL: https://structuralengineeringbasics.com/what-are-beams-and-columns-building-construction/ (cit. on p. 1).

[2] J. O. Bird and P. J. Chivers. "36 - Simply supported beams". In: *Newnes Engineering and Physical Science Pocket Book*. Newnes, 1993, pp. 278–286. ISBN: 978-0-7506-1683-6. DOI: https://doi.org/10.1016/B978-0-7506-1683-6.50039-4. URL: https://www.sciencedirect.com/science/article/pii/B9780750616836500394 (cit. on p. 1).

[3] Minas Lemonis. *Simply Supported Beam Calculator*. 2020-05. URL: https://calcresource.com/statics-simple-beam.html (cit. on pp. 1, 2).

[4] Wikipedia contributors. *Euler-Bernoulli beam theory — Wikipedia, The Free Encyclopedia*. [Online; accessed 20-January-2023]. 2022. URL: https://en.wikipedia.org/w/index.php?oldid=1125198888 (cit. on p. 1).

[5] The Drasil Team. *Drasil*. 2023-01. URL: https://github.com/JacquesCarette/Drasil (cit. on pp. 2, 3).

[6] Simon Marlow et al. *Haskell 2010 Language Report*. https://www.haskell.org/onlinereport/haskell2010/. 2010 (cit. on p. 3).

[7] Jason Balaci. *Maintaining 'Creating Your Project in Drasil' Wiki Tutorial*. GitHub Repository Discussions. 2023. URL: https://github.com/JacquesCarette/Drasil/discussions/3194#discussioncomment-4661064 (cit. on p. 3).

[8] Jason Balaci. *Topic #1: De-embedding Drasil*. GitHub Repository Discussions. 2022. URL: https://github.com/JacquesCarette/Drasil/discussions/3003 (cit. on p. 3).