# Ernesto Lopez,

## NSF Graduate Fellow

**NSF GK-12 Project:** Northeastern University
GK-12-PLUS (Partners Linking Urban Schools)
URL: http://www.gk12.neu.edu

**Thesis Title:** Vibrations and Fluid Structure Interactions in Web Handling Systems

**College/University:** Northeastern University

**Research Advisor:** Prof. Sinan Müftü

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**Degree Sought**
PhD, Mechanical Engineering

**University Department and/or Lab**

MIE Dept.

**Research Focus**

Machine and Design

**Description of Research**

This work is motivated by the idea that in understanding the engineering principles governing web handling systems and roll-to-roll manufacturing their limits can be learned and exceeded. Two problematic situations are addressed:

- The manufacture of certain products requires that there be no contact between guides and the web. In these situations an air reverser is utilized. An air reverser is a pressurized hollow drum with holes on the surface to provide the air cushion. The cushion of air protects the web from any contact damage. The aspect ratio of the webs longitudinal length versus web thickness during manufacturing makes the process highly susceptible to transverse vibration. Free vibration analysis of a thin tensioned web, wrapped around a reverser was studied. The effect of helix angle was considered. The eigen-problem was formed using a two-dimensional beam model and a full three-dimensional finite element model. Design parameters such as tension, radius of cylinder, wrap angle, width of the web, lengths of non-wrapped web and helical wrap angle were studied. It was seen that the free edges cause a frequency clustering of the lateral-modes about the dominant longitudinal-mode. It was also seen that the effectiveness of the plate-shell junction to act as a stiff support depends on problem parameters. Eigenmodes with same mode-shape numbers are observed in symmetric and anti-symmetric fashion about the center of the plate, for configurations with equally long unwrapped sections. The results also showed that the first natural frequency is reduced at large helical angles for the parameters studied.

- The fluid structure interaction between a web and air reverser has been previously modeled under the assumption that tension was constant and chord length does not change, but for large deflections this may not be the case. The effect of large deformation of web on the mechanical and fluid domains of an air reverser will be investigated. For this study, to simplify the mechanics, the web and air reverser are modeled two-dimensionally. The questions to be answered here are: How does the chord length change under large deformation? How must the fluid mechanics be modeled under large deformation? Two numerical models will be developed to answer these questions. Fluid structure interaction model 1 will consist of an elastica beam coupled with a fluid model utilizing one-dimensional lubrication flow. Fluid structure interaction model 2 will consist of an elastica beam coupled with a fluid model utilizing a two-dimensional Navier-Stokes model. The following web guide design parameters influence web deformation and will be studied: longitudinal tension, radius of the cylinder, wrap angle, lengths of incoming/outgoing webs and supply pressure will be studied. Experiments will be carried out for verification of models developed.

**Example of how my research is integrated into my GK-12 experience**

The scope of my research encompasses many physical disciplines such as structural mechanics, fluid mechanics and vibrations. The foundations for many of these topics are introduced during an AP Physics class. It is my hope that I can incorporate advanced topics related to these types of problems relating to my research and state-of-the-art work.