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A Mathematics Model for th Acoustic and Seismic Properties of the Landmin Detection Problem

Outline of Topics Introduction Sabatier's Model The Analytical Model COMSOL® Future Work Acknowledgements Presented at the COMSOL Conference 2008 Boston

A Mathematical Model for the Acoustic and Seismic Properties of the Landmine Detection Problem

ENS Michelle Mattingly, USN

U.S. Naval Academy

Professor R. Malek-Madani, Mathematics Department, Professor K. McIlhany, Physics Department

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Mathematical Model for the Acoustic and Seismic Properties of the Landmine Detection Problem

Outline of Topics

Introduction Sabatier's Model The Analytical Model COMSOL® Future Work Acknowledgemen

1 Introduction to the non-metallic landmine problem

- 2 Current research in acoustic to seismic landmine detection
- 3 Analytical Model
- COMSOL[®] Comparison
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- 5 Future Work and Acknowledgements

Outline of Topics

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Introduction

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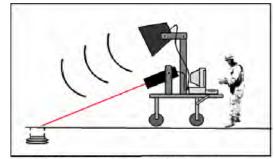
- Non-metallic landmine detection problem originates from World War II
- Limited methods available to solve the non-metallic landmine problem
 - Explosive Vapor Techniques
 - Acoustic to Seismic Technology

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Sabatier's Model

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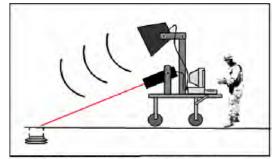
Sabatier's Proposed Seismic to Acoustic Landmine Detection Apparatus

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Sabatier's Model

Sabatier's Proposed Seismic to Acoustic Landmine Detection Apparatus

• Landmine resonances occur when the landmine vibrates at maximum amplitude at a particular frequency, known as the resonant frequency.

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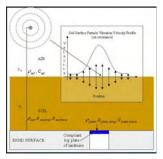
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Physical Representation of Sabatier's Experiments

• Understanding the physical processes in Sabatier's experiments is necessary for creating the mathematical models.



 PROJECT GOAL: Theoretically predict the resonances and soil surface velocity profiles obtained by Sabatier

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Important Notes

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- Loudspeaker is represented as a point source.
- Maximum soil displacement occurs over the mine at resonant frequencies.
- Simplified damping was applied to the system, and other losses were ignored.
- Soil was modeled as an effective fluid.
- Solved the linear, time harmonic, acoustic wave equation: $\nabla^2 p = -k^2 p.$

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Mathematica Model for the Acoustic and Seismic Properties of the Landmine Detection Problem

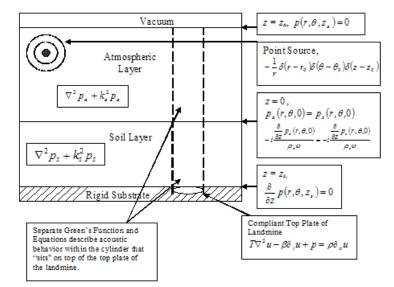
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Analytical Model

The Membrane Problem



Analytical Model

The Analytical Solution

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$$w = \frac{1}{i\omega\rho_{a}}\sum_{m=0}^{\infty}\sum_{n=1}^{\infty}J_{m}\left(\sqrt{\zeta_{mn}}r\right)A_{mn}\cos\left(m\theta\right)\phi_{mn,air}'(z)$$

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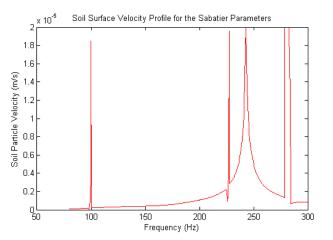
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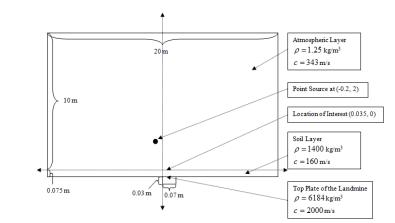
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Analytical Model Soil Surface Velocity Plot



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Comsol Implementation Diagram



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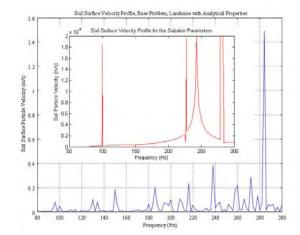
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Comsol Prediction and Comparison



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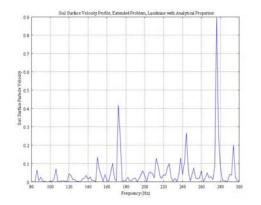
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Comsol Prediction for the Extended Model



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Extension of the Base Model



Landmine

Detection Problem ENS

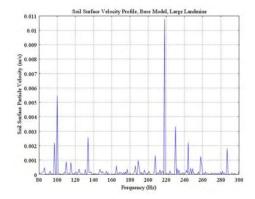
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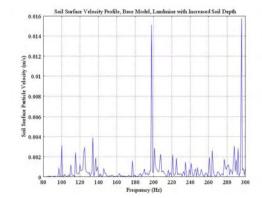
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Extension of the Base Model



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Predictions from the membrane problem on the physical limitations of the acoustic to seismic landmine detection technique

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 Predictions from the membrane problem on the physical limitations of the acoustic to seismic landmine detection technique

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Future Work Acknowledgements • Landmine property limitations - smallest size for detection, density, tension

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 Predictions from the membrane problem on the physical limitations of the acoustic to seismic landmine detection technique

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- Landmine property limitations smallest size for detection, density, tension
- Soil limitations depth, layering, porosity, effective fluid model

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- Predictions from the membrane problem on the physical limitations of the acoustic to seismic landmine detection technique
 - Landmine property limitations smallest size for detection, density, tension
 - Soil limitations depth, layering, porosity, effective fluid model
- Possibility of obtaining an analytical solution or another numerical solution for the extended problem.

Acknowledgements

- Model for the Acoustic and Seismic Properties of the Landmine Detection
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- Office of Naval Research (ONR)
- Dr. James Sabatier of the National Center for Physical Acoustics
- Prof. J. Buchanan, USNA Mathematics Department and Prof. M. Korman, USNA Physics Department
- Dr. David Burnett, of the Naval Surface Warfare Center
- Dr. Dave Bradley of the Applied Research Lab, Penn State University