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SIMIODE A SYSTEMIC INITIATIVE FOR MODELING INVESTIGATIONS & OPPORTUNITIES WITH DIFFERENTIAL EQUATIONS

SCUDEM V – 2020

Problem A: Decay of Oil Agglomerates From The Deepwater Horizon Accident

The impacts from the Deepwater Horizon accident in 2010 [3] are still felt across the Gulf of Mexico [2]. There are beaches where oil remains buried, and it is still an open question as to how much longer the oil and its byproducts will remain. In a recent study [1], clumps of the remaining oil were found and appear to be forming into small, golf ball sized clumps. The researchers explored the role of the depth that the clumps were buried as well as the porosity of the sands in which the clumps are buried.

When examining the role of depth and porosity the researchers assumed exponential decay models to determine the change in the clumps over time. These models provided good estimates for some aspects of the chemicals, but they did not provide a good fit for the change in overall mass. Assuming that microbial action is the primary agent for breaking down the chemicals within the clumps, can a better model be developed?

Focusing on the mass and assuming the other degradation observations are correct, develop a model of the evolving mass of a single clump of material. The model should account for the depth and porosity of the sand in which the clump is buried.

Your results should address the following:

- A description of the model including all assumptions.
- Determine the mass of the clump over time.
- Compare your results to the mathematical model in the paper [1] (given in Figure 2).
- Estimate the time required before the amount of materials in the beaches will be reduced to ten percent of the current amount due to the clumping.
- Estimate the impact of removing a small top layer of sand from a beach. What would the reduction in time be for a given amount of sand removed as a way to mitigate the long-term impact?

References

[1] Bociu, I., B. Shin, W.B. Wells, *et al.* Decomposition of sediment-oil-agglomerates in a Gulf of Mexico sandy beach. *Sci Rep* 9, 10071 (2019). https://doi.org/10.1038/s41598-019-46301-w. Accessed 23 August 2020.

[2] Deepwater Horizon – BP Gulf of Mexico Oil Spill, United States Environmental Protection Agency. https://www.epa.gov/enforcement/deepwater-horizon-bp-gulf-mexico-oil-spill. Accessed 23 August 2020.

[3] David Barstow, David Rohde, and Stephanie Saul. Deepwater Horizon's Final Hours. *The New York Times*. 25 December 2010. https://www.nytimes.com/2010/12/26/us/26spill.html. Accessed 23 August 2020.

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Problem B: Spinning A Wheel

A popular video [1] has been shared in various social media forums of a bird that likes to perch on the edge of a bicycle wheel and move its body so that the wheel spins through a full revolution. The movement of the bird is similar to the way a person can change their position on a swing in a way that can increase the amplitude of their oscillations. The bird can do this from a still start but is starting while at the top of the wheel.

Can you replicate and model this phenomenon? Assume that you have a bicycle wheel mounted vertically, and a small device is mounted on the wheel. The device can move a small mass attached to the wheel and hence the wheel. Is it possible to find a way to move the mass so that the wheel and the mass can rotate? Is it possible to do this if the mass only moves in the tangential direction or can you also do so with a radial component as well?

Your results should include the following:

- A complete description of your apparatus and assumptions.
- A complete description of how it moves.
- Describe the equations of motion.
- Describe the necessary initial conditions to increase the amplitude of any oscillations. For example, can this occur if the apparatus is initially completely still with the weight at the bottom, or do you have to impart some initial rotational velocity or a specific position?
- Does the motion of the object have to change as the wheel's angular velocity changes?
- Describe the maximum speed that the wheel can spin.

References

[1] Cockatoo Loves Going Around In Circles, https://www.youtube.com/watch?v=F1P6IWPOJl8, Last accessed 28 July 2020.

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Problem C: Managing Different Dispute Resolution Strategies

In 2011 the country of Sudan split into Sudan and South Sudan. The split followed many years of strife. Unfortunately, the split itself led to further violence, which in return resulted in the creation of refugee settlements in Uganda. There are many aspects of the dynamics of the lives of the people within these camps that are not understood, and the camp settlements themselves are the subject of observation and research.

The settlements in Uganda were originally formed by different outside organizations. Each organization tries to impose its own methods to resolve disputes that may arise between people in the settlement. For example, some organizations may set up a system in which people are expected to negotiate with one another, while another organization may prefer to create a system in which outside arbiters make decisions by which others must abide. Another common approach is to require the use of a mediator who acts as a guide to help the parties involved find their own solution to which all can agree.

In a study of some of the refugees who fled South Sudan and moved to settlements in Uganda, it was found that many people also brought their own systems and preferences with them and sought to incorporate their own traditions into the process. What happens when multiple practices and traditions are brought together? How do the different practices come together and create a new system in the context of a refugee settlement? How does a process of dispute resolution change and evolve?

There are many different strategies that are available for dispute resolution, and this can be a complicated problem. Instead, we focus on the three methods described above: negotiation, arbitration, and mediation. Assume that these methods are available in a settlement and as different people move into the settlement, they have traditions and initial preferences as to how to resolve disputes. Over time how does the community evolve and adjust as people are brought into close contact with one another? Does the community tend to move toward a common approach or do the different approaches tend to remain in place?

Your results should include the following:

- A description of the situation and community including assumptions about how people interact over time.
- A description of how different parties agree to a method to resolve a dispute.
- A mathematical model of how the preferences of a settlement's population change over time.
- A description of what happens when new people move into a settlement and a discussion of how their preferences change the current trends within the settlement.
- Predictions for the long-term practices that will be adopted by the people in the settlement.

References

[1] How refugees resolve disputes: insights from a Ugandan settlement. Vancluysen, Sarah and Bert Ingelaere. https://theconversation.com/how-refugees-resolve-disputes-insights-from-a-ugandan-settlement-142508. Accessed 23 August 2020.