MATH 2121 **Mathematical Modeling and Simulation** **Spring 2025**

Problem Set 1

(Out Thu 01/16/2025, Due Tue 01/28/2025)

Submissions are to be done by sending an email with subject `MATH 2121: Problem set 1` to the course instructor, containing: all requested Matlab files (called `yourfamilyname_problem1X.m`), plus a single file (PDF preferred), called `yourfamilyname_pset1.pdf`, that contains all requested explanations.

Problem 1

Download and run the Matlab file `temple_abm_mexican_wave.m` from the course website `http://faculty.cst.temple.edu/~seibold/teaching/2025_2121/`

(a) Explain first, why waves are possible to arise in the model. Second, explain some of the key shortcoming of the model, i.e., which aspects of real world Mexican waves does not model fail to capture.

(b) Modify the model so that it is possible to have waves traveling to the left and waves traveling to the right. [Hint: When agents are affected by only immediate neighbors, it is impossible to achieve the objective by allowing only two possible states (0 or 1) per agent. One possible approach (which would also make the model closer to reality) can be to introduce more than two states, capturing the process of vertical movement of agents, e.g., 0="sitting and observing neighbors", 1="rising", 2="standing", 3="descending").] Implement your model and encode an initial state that produces two waves: one traveling to the left and one wave traveling to the right, set up so that eventually the two waves will collide. Submit your new program under the filename `yourfamilyname_problem1b.m` . Describe the behavior that the model/simulation produces when the waves collide, and argue whether the observed behavior is realistic or not.

(c) In reality, a wave created by the spectators in a stadium tends to be several people wide. Modify the model so that it produces waves that are at least 5 agents wide (i.e., at any time, at least 5 adjacent agents are not sitting down), even though the initial number of non-sitting agents is not exactly 5. [Hint: Here you may want to introduce agent–agent interactions that are non-local in the sense that any agent is affected by other agents that are further away than its immediate neighbors.] Implement an interesting initial condition in your program. Submit your new program under the filename `yourfamilyname_problem1c.m` .

(d) Finally, we should consider the fact that real humans are not executing their motions perfectly; there is always some noise in their actions. Nevertheless, Mexican waves tend to travel in a stable fashion, even in light of small random perturbations. Now modify/expand your previous model (ideally, the one that produces waves that are multiple agents wide) to allow for a random component in the agents' behavior. Decide what type of randomness you feel is realistic (e.g., by inspecting videos of spectator waves on the internet). Write a brief description of your model, and argue why you think it is realistic. Implement your model and equip it with an interesting initial state. Submit your new program under the filename `yourfamilyname_problem1d.m` .