Project 2: Granular Materials

5/6/2025

100 Points Possible

Attempt 1

In Progress
NEXT UP: Submit Assignment

Add Comment

Unlimited Attempts Allowed

Details

This project is based on **Project 8.26** on pages 303-304 of the Gould Text. Begin by reading the entire project carefully.

All of you did a good job of working through the prompts in the previous project, responding to them in a thoughtful way, and writing in the required format. Generic advice for improvement is to use complete sentences, paragraphs, and sections. In the interpretation section, elaborate a non-trivial understanding of the numerical experiments, provide citations where possible, demonstrate the simulations are working as they should, and reduce superfluous code and/or Python output from your submission.

Respond to the book **prompts a and b.** Do not consider c. In addition, do the following.

- Implement a ramp and a gravitational force on the particles. Have the particles drop from above the ramp, strike the ramp, and slide down experiencing a contact force with the ramp. Include a few snap shots of this process to demonstrate it worked.
- Add two ramps to form the walls of an hour glass - they will look like this "\/" where there is a narrow gap for particles to fall through. Fill the hour glass with particles and allow them to exit. Again, show plots of the particles to demonstrate it is working.
- Using your simulation platform answer the following question: *With a fluid, the rate the fluid leaves a funnel is proportional to the height of the fluid. In an hour glass, the rate the sand grains fall is constant. Why?*
- In answering the above question, make sure to consider the sensitivity of your result to: the slope of the sides, the size of the gap, the size of the particles, and the size of the damping (friction) which in equation 8.59 is gamma. Monitor the rate particles fall through the gap and the forces between particles.
- More particles might reveal more physics. Consider **problem 8.21** as an optimization. Doing so can only help, and not hurt my assessment - ie this is 'extra credit'.

As before, submit your solution as a Jupyter Notebook. Note that you can use Mujoco for this project, if you like. I can't promise it will work, but it certainly looks possible. Note that only a 2D analysis is required.

Finally, on the force. I see that what the book suggests will work, but it may make implementing the ramp or walls more difficult. Consider instead the classic Hooke's law type force. This is convenient because it is proportional to the overlap of the particles. It can be generalized to be proportionate to the overlap of a particle and a wall. Mathematically, the force would then be

$$\mathbf{f}(\mathbf{r}_{ij}) = -k(R_i + R_j - r_{ij})\frac{\mathbf{r}_{ij}}{r_{ij}} + \gamma(\mathbf{v}_{ij} \cdot \mathbf{r}_{ij})\frac{\mathbf{r}_{ij}}{r_{ij}^2}$$

Where R_i, R_j are the radii of particles i and j, and the force is zero if $r_{ij} > R_i + R_j$. Part of the project is determining appropriate values of the spring and damping constants, but k~1 and γ ~ .3 should be a starting point. NOTE: I found it easiest to write a function called wallConstraint that I call inside the force function. That function adds to the forces between particles, forces between particles and the walls.

View Rubric

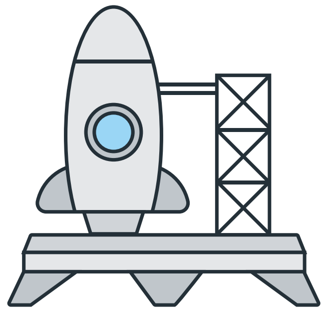
Project Rubric

Criteria	Ratings	Pts
Organization view longer description		/ 5 pts
Methods view longer description		/ 10 pts
Analysis view longer description		/ 40 pts
Interpretation view longer description		/ 15 pts
Data Presentation view longer description		/ 15 pts
Mechanics view longer description		/ 10 pts
Introduction view longer description		/ 5 pts
		Total Points: 0

Choose a submission type

Upload

More



Choose a file to upload

or

Webcam Photo

Canvas Files

Submit Assignment