These grains can be solid, liquid or dust

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(PhysOrg.com) -- Take a walk along the beach and you might marvel at any number of things: the cresting waves, the occasional scuttling crab, the shells and odd shapes of driftwood that wash ashore.

Rich Evans marvels that the beach and its countless grains of sand reliably support the weight of thousands of people, from surfers to sunbathers to castle-builders.

Sand and other grain particles can behave like a dust, a liquid or the solid that beach-goers take for granted, says Evans, who will complete a five-year double degree in May.

“In a sandstorm,” he says, “grain particles behave like a dust. If you pour sand out of a cup, it acts like a liquid. On the beach, sand behaves like a solid.”

Evans majors in chemical engineering and in integrated business and engineering (IBE). Last year, he studied grain particles in Opportunities for Student Innovation (OSI), a one-year class in which high-ranking chemical engineering seniors do research under the supervision of faculty or industry mentors.

Evans inherited a project begun by Ken Ford ’08 Ph.D. and worked on it with Colin Armstrong ’09 and chemical engineering Profs. Hugo Caram and James Gilchrist. The five researchers have written a paper that is being considered for publication in a journal.

Utilizing a subwoofer, an accelerometer and more

Why study particles? Engineers have written equations that describe the dynamics of liquid flow, says Evans, but not the flow of granular particles. There are practical reasons. Particle flow patterns influence whether grains form a homogeneous or heterogenerous mixture. And a better understanding of particle behavior in suspensions can have applications in mining, pharmaceuticals and disease detection.

In their study, Evans and his team filled a column with fine sand, glued it to a subwoofer, or speaker, and turned on the subwoofer. An accelerometer atop the column measured how fast the column shook in response to vibrations from the subwoofer's bass frequencies.

Meanwhile, a generator and amplifier charted the amount of energy transmitted from subwoofer to column, and the movements and interactions of sand grains inside the column. The team inserted a pencil-like probe into the center of the column and toward its base to measure vertical oscillation, or the fluctuations in density of the sand grains.

"Our goal was to understand the behavior of the sand particles as the sand makes the transition from solid to liquid," says Evans. "When the column of sand is static, a lot of force is required to push a pencil through the solid to the bottom. When we crank up the movement of the subwoofer, energizing the grains of sand, it becomes easier to force the pencil into the sand.

"As you increase the magnitude of the vertical oscillation, the bed starts moving. At some point you observe a drop in density, indicating you've moved from solid to liquid state."

Evans wonders whether that transformation represents a linear progression, accomplished in gradual, discrete intervals, or a more nonlinear progression marked by a sudden and unpredictable drop in sand-particle density.

"Upon the initial agitation of the sand, a low density originates at the top of the column and presses downward with increasing acceleration. Is this a linear progression, or is there a critical acceleration moment so that at some point the entire bed goes? So far, the evidence is inconclusive."

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