Traffic Operations Study:

Hallway Congestion

THE CHALLENGE
Observe, measure, and quantify the interaction between pedestrian density and travel speed in a hallway.

GRADE LEVEL
Middle School.

ACTIVITY DURATION
Approximately 5 to 10 minute introduction, 5 minute observation activity, 10 to 15 minute experiment activity, 10-15 minutes of calculation/report time, followed by a 5 to 10 minute discussion.

MATERIALS
• Timers/ Timing Devices
• Pencils/ Pens
• Paper/ Notebooks

SET UP
This activity will primarily occur in a hallway (ideally one with an overlook location so that the hallway can be viewed from above) and a classroom with tables/chairs. You can always substitute a sidewalk or walking area if a hallway is unavailable.

ACTIVITY
Provide a brief introduction to the speed and density concepts. Some important talking points for the introduction are: What do the terms mean? How are they measured? Why do we care about them? Try to break the concepts down into manageable chunks of information and relate them to things the students will already be familiar with.

Show a brief video of a hallway or roadway operations to supplement your explanation. (Note: many state DOTs have live-streaming video of highways that you can watch remotely.)

Introduce the activity: “Now that you know how to calculate speed and density, I want you to explore the relationship between the speed and density of people walking through a hallway. You will do this through real-world observations and through experimental testing.”

Take the students out into the hallway during a passing period. If this is not possible, show them a short video of people walking down a busy hallway or sidewalk. Ask the students to take notes on how the perceived speed changes based on the number of students in the hallway and how the speed is altered based on the size of the student groups (e.g., if four students walk side-by-side, how does that affect the rest of the students using the hallway?)

Once the hallway is clear, the students will run their own experiments as a large group. Decide on a path through the hallway, with a set beginning and end. Have one or two of the students measure the distance and width of the path. Next, send a few students walking down the hallway and ask the students to measure the time it takes for the students to complete the path and record how many students are in the group. Repeat this procedure, adding more and more students each time, until all but one student (the observer) is walking down the hallway.

After 10 to 15 minutes, ask the students to regroup, and come back into the classroom for calculations/report time. Have the students calculate the area of the path by multiplying the length and width of the path. Then have the students calculate the speeds, in feet per second, for each group size, using the length and time measurements. Using a hand-drawn graph or

Velocity (speed) = Distance ÷ Time
Density = No. of Vehicles per Lane per Mile
Congestion forms as the number of items (like vehicles or people) moving in a constrained space increases.
Jam Density = density at which travel breaks down (on a freeway, about 200 vehicles per lane per mile)
Critical Density = density at which maximum traffic flow occurs
Microsoft Excel-like program, have the students create speed vs. density (in students per square feet) plots. Ask them to draw conclusions about the relationship between speed and density from these plots. During this time, walk around the students to answer questions and provide hints as needed.

After 10 to 15 minutes, ask the students to share their findings with the class and close with a group discussion.

**FOR DISCUSSION**
Talk with the students about the relationship between speed and density. Ask the students to think about various ways they could either increase the speed or lower the density (e.g., widen the hallway, space out the student departures from the beginning of the path, etc.) Walk them through the various ways that engineers put these ideas into practice on roadways, sidewalks, and more!

**LEVEL OF DIFFICULTY**
**IMPORTANT:** It is crucial to have a conversation with the classroom teacher prior to performing the activity. This will aid in understanding the educational level of the class (for example, regular classes vs. gifted & talented or AP classes) which will help determine the appropriate level of difficulty of the materials and items for discussion.

**Increase difficulty by:**
1. Increasing the number of time measurements taken during the experiment (e.g., one time per student).
2. Increasing the complexity of the path.
3. Asking the students to calculate statistics from the vehicle speeds, and/or the relationship between speed and density.
4. Having the students draft a report, summarizing their observations, calculations, and conclusions.

**Decrease difficulty by:**
1. Reducing the complexity of the path.
2. Removing the students' responsibility for timing or taking notes, and only having them walk down the hallway and observe the differences in how it felt to walk down the hallway with more or fewer people.
3. Removing the experimental portion of the activity.