Document ID: 10_02_00_1
Date Received: 2000-10-02 **Date Revised**: 11/20/02 **Date Accepted**: 11/29/02
Curriculum Topic Benchmarks: S12.4.7, S15.3.2, S15.3.3, M4.3.3, M4.4.3, M8.3.3
Grade Level: [6-8] Middle School
Subject Keywords: reaction time, experimental psychology, gravity, acceleration, Newton's Laws
Rating: moderate

The Fall of the Ruler

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From: The PUMAS Collection http://pumas.jpl.nasa.gov

Measuring Human Reaction Time [RT] on the Cheap

Summary: This activity teaches how an ordinary ruler can measure (human reaction) time.

Human Reaction Time [RT] is defined as the time it takes a Human (you!) to react to an event such as a light or a sound. Reaction Times come into play during emergencies ("Quick! A cow is on the tracks! Stop the train!") and more ordinary events (stopping at a stop light, answering a ringing phone, turning to face someone who's talking to you). Reaction Times are important for traffic design (from the duration of the Yellow Light to the length of a Left Turn lane at busy intersections); for computer interface design; and are important in brain research (what types of decisions take the most time, etc). Reaction Times are also diagnostic for certain types of injuries.

Your reaction time is determined by several factors:

- The conduction speed of the electrical impulses in your nerves:
  "The light is red" (optic nerves to brain)
  "Step on brake" (brain to motor nerves in leg)
- The time it takes to make a decision:
  "Is the light really red?"
  "What should I do when the light turns red?"
- Many other things, such as:
  how fast muscles can move,
  how intense the light or sound was,
  one's stress level, expectation, practice, etc.

(For additional background: Many college-level "Introduction to Psychology" books discuss Human Reaction Time measurements and how they vary according to input and action required.)

Human RT was first measured in the mid-19th Century; its measurement usually involves equipment such as switches, timers, lightbulbs or bells.
(This website: http://www.barnard.edu/psych/museum/b_museum.html#1 shows interesting pictures of early apparatus used for measuring RTs.) However, you can measure human RTs using a simple ruler that has been calibrated in milliseconds (msec), rather than inches or meters.

Gravity causes objects to drop towards Earth. The acceleration due to Gravity is incorporated in the equation relating distance to time:

$D = 0.5 * A * T^2$
where A is approximately 10 meters / $second^2$ T is time in seconds, and D is distance in meters.

Thus, a ruler drops this distance in 1 second:
$D = 0.5 * 10 * (1)^2 =$ 5 m (about 200 inches)

and in 0.1 second (100 msec), the distance in meters is
$D = 0.5 * 10 * (0.1)^2 = 0.5 * 10 * 0.01 = 0.05$ meters (about 2 inches)

Suggested Activities

(1) Students can plot time (in msec) versus distance (in inches or meters) for times between 50 and 250 msec. They then can transfer their values to a ruler, marking off values between 100 and 250 msec in 10 msec increments, converting a standard ruler into a "time ruler." (The correct table is shown at the end of this write-up.) Note that air resistance is negligible in this case.

(2) Students can pair off and measure each other's Reaction Times, as:

One student holds the ruler in midair, while the other student holds his or her fingers at the bottom of the ruler (marked at "0 msec"), ready to pinch it the ruler. Without warning, the first student lets go of the ruler, and the second pinches the ruler as quickly as possible to stop it falling. The distance the ruler drops is a good estimate of the student's reaction time.

The class can average each student’s RT, calculate means and variances, and/or produce a scatterplot of the measurements to see if there are any outliers (likely instances where students began their pinch before the ruler was dropped; to avoid these, one might construct a penalty for any "flinch-pinches").

(3) The third activity relates to an old parlor trick. The teacher offers to give away a bill ($5, $10) if a student can pinch the bill before it drops past their fingers. (The position of the fingers must be right at the bottom of the bill, as described in Activity Two.) After demonstrating that the task of catching the bill is nearly impossible, students can calculate the human RT required to catch the bill.

NOTE: *The author once gave away a $20 bill to one of his students because the limits of human RT are close to catching the bill; my student was lucky and started to pinch her fingers just before I let go of the bill. If teachers do not want to live dangerously, they could pose the parlor trick as positioning the fingers one inch above the bottom of the bill; catching the bill during that 5-inch drop requires an RT that is considerably smaller than the fastest human RT.*

For Advanced Studies

The PUMAS example “Right Place, Wrong Time” extends this experiment by asking students to replicate an interesting anecdote about an incorrectly manufactured time-ruler.

The table below shows the relationship between time (in msec) and distance. In this table, we've used a more exact figure for gravity (9.8 meters per second squared):

Time (msec)	**Distance** (meters)	**Distance** (inches)
50	0.012	0.482
60	0.018	0.694
70	0.024	0.945
80	0.031	1.235
90	0.040	1.563
100	0.049	1.929
110	0.059	2.334
120	0.071	2.778
130	0.083	3.260
140	0.096	3.781
150	0.110	4.341
160	0.125	4.939
170	0.142	5.575
180	0.159	6.250
190	0.177	6.964
200	0.196	7.717
210	0.216	8.507
220	0.237	9.337
230	0.259	10.205
240	0.282	11.112
250	0.306	12.057

The author thanks Ron Menendez and Chuck Watson for their help in preparing this example. The author's academic background is in Experimental Psychology, having done fundamental research in how the human auditory system processes complex sounds. His proudest moment as a graduate student wasn't getting an inhumanly small Reaction Time, but testing a major symphony orchestra for its frequency perception. The only prior study of orchestra musicians (75 years earlier!) was of the Vienna Court Orchestra and included Gustav Mahler as a listener. The author's current work involves speech technology for telecommunication services.