Cellular Phones Helping To Get a Clearer Picture of Kinematics

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The main purpose of this paper is to add to the list of examples of how cell phones may be used as teaching tools in the classroom.[1] One very interesting example of this comes from the study of projectile motion, the classical "cannon ball" problem. This problem is central to the study of kinematics, the very first topic a student meets in physics. Our approach exploits the fact that these days almost all students carry cellular phones and the vast majority of the phones have built-in cameras.

Figure 1 shows the experimental procedure. A photograph of a water jet from a hose was taken, using a ruler as a reference scale, and was printed to get the *x*-*y* curve. The jet is made of water drops, which emerged almost continuously from the hose spout. After printing the picture, the students drew a pair of *x* and *y* axes and got the set of (*x*,*y*) coordinates of the projectile motion and built a table. The data were then fitted to Eq. (1) using Origin graphing software[2], as shown in Fig. 2. Table I shows parameters *a*, *b*, and *c*. Setting[3] $b = \tan\theta_0$ and

$$c = \frac{-g}{2(v_0 \cos\theta_0)^2},$$

with $g = 981$ cm/s^2, we find $\theta_0 = 78.8 \pm 0.5°$ and $v_0 = 223 \pm 5$ cm/s.

Other similar experiments employing camera cell phones may be done outdoors, thereby helping to show students the links between physics, mathematics, and other natural sciences. For example, during a trip to a botanical garden, students may measure the velocity of floating leaves on a canal, verifying the

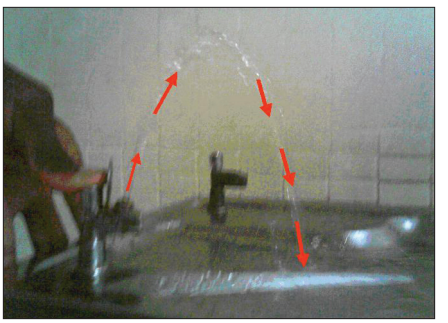

Fig. 1. Photograph of a water jet from a hose.

Table I . Fitting parameters of a second-order polynomial ($y = a + b\,x + c\,x^2$) to the projectile as shown in Fig. 2 (*y* and *x* are in centimeters).

parameter	value
a	-1.03 cm
b	5.07 cm
c	-0.26 cm^{-1}

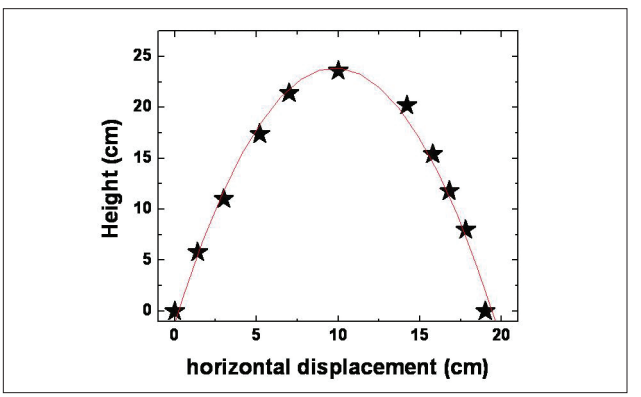

Fig. 2.

existence of surface tension and obtaining a value for the water viscosity. Or they may take pictures of thunderbolts and extract their fractal dimension, besides registering the type of clouds usually associated with storms. The possibilities are many, showing that cell phones are much more than a disruptive ring during a lecture… they are a powerful teaching tool.

References

1. See, for example, Dave Van Domelen, "Teaching light polariztion with cell phones," *Phys. Teach*. **45**, 469 (Nov. 2007), and E.C. Hammond and Meron Assefa, "Cell phones in the classroom," *Phys. Teach.* **45**, 312 (May 2007).
2. See http://originlabs.com (temporary web address).
3. David Halliday, Robert Resnick, and Jearl Walker, *Fundamentals of Physics*, 6th ed. (Wiley, 2001), p. 65.

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Missing Matter

Astrophysicist Todd Tripp and astronomer Edward Jenkins of Princeton University... and astrophysicist Blair Savage of the University of Wisconsin, Madison, found a clue to the missing matter's whereabouts when they pointed the Hubble [telescope] at a particularly bright, young quasar and dissected its light. In the ultraviolet region of the quasar's spectrum, the researchers found pairs of absorption lines, wavelengths at which the intensity of the light dipped. The lines indicated that oxygen VI, oxygen stripped of five of its eight electrons, lay between the quasar and Earth, soaking up some of the light. And where there's oxygen there's sure to be hydrogen, as hydrogen is by far the most abundant element in creation. So, as the researchers report in the 1 May issue of Astrophysical Journal Letters, they concluded that intergalactic space is filled with clouds of invisible ionized hydrogen. 'This brings us toward a census of all the matter in the universe,' says Jane Charlton, an astronomer at Pennsylvania State University, University Park.[1]

1. Adrian Cho, "Astronomers detect more missing matter," *Science* **288**, 947 (May 12, 2000).