TAKE IT TO THE MAT

A NEWSLETTER ADDRESSING THE FINER POINTS OF MATHEMATICS INSTRUCTION

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Whether teaching algebra, geometry, trigonometry, statistics, or calculus, application is a crucial element of the learning experience. The *Teacher Expectancies* include the component Linkage. Linkage is one part of a balanced delivery of instruction and includes connections to related concepts in mathematics and other disciplines, and practical application. Yet, there are pitfalls to avoid in teaching applications of mathematical concepts and procedures. That is the subject of this issue of *Take It to the MAT*.

One error in teaching applications is that of *mis*-application. Sometimes we get so caught up in trying to answer the kid question, "Where is this used?" that we create applications that are not real, or at least have some flaws. Our textbooks are sometimes guilty of this, too. The danger is that it leaves students with misconceptions that will need to be "untaught" down the road, if the opportunity to do so even presents itself. One common place is in teaching quadratics. Take these problems from Algebra I texts as examples:

> The function $h = 40 - 4.9t^2$ represents the height (in meters) of a rocket after t seconds. Find the height of the rocket after 2 seconds.
>
> A rocket is fired from the ground and the height of the rocket after t seconds is $h = 75t - 4.9t^2$. Find the time when the rocket returns to the ground.

Photos courtesy of NASA

Close your eyes and picture a rocket being fired from the ground. What did you see in your mind? What I see is shown at right. The top photo shows a Delta II rocket at launch; the bottom photo is the rocket several seconds later. Notice that in both cases, the rocket's motors are still running, providing thrust. So what? Well, if these pictures are indicative of what you (and kids) imagine, then the problems above are mis-applications.

The misconception comes from treating a rocket as a projectile. A projectile is an object that has been given some initial motion through throwing, firing, etc. without having the ability for self-propulsion. When the rocket motors are shut off, either by choice or exhaustion of fuel, then it becomes a projectile. While the rocket is still thrusting, however, it is not a projectile.

The reason this matters is that the quadratic function used in projectile motion,

> $h(t) = h_0 + v_0 t + \frac{1}{2}gt^2$, where h = height from a reference point (usually ground) at time t, h_0 = height at $t = 0$, v_0 = velocity at $t = 0$, and g = acceleration due to gravity (-9.8 m/s^2 or -32 ft/s^2 on Earth),

only applies to those objects that have no forces acting on them with the exception of gravity—no thrust, no propulsive forces. (We are ignoring air resistance as a force here as it involves differential equations.) Also, the equation **only** applies to **vertical** motion, or the vertical component of the projectile's motion.

Thus, for the two textbook exercises given, the equations provided are only accurate if the rocket has finished thrusting and now moves only as a result of its own inertia and gravity. If that is the case, what does that tell you about where and how the rockets are moving at $t = 0$?