TEAMS Competition - high school math guidelines

The TEAMS competition involves open ended problems requiring critical thinking, problem solving skills and mathematics. As a guide, the level of mathematics involves:

Unit conversions	
Algebra	*Systems of equations*
Geometry	*Volumes, surface areas, relationships between different shapes and surfaces*
Trigonometry	*cos, sin, use of trig identities to solve problems*
Precalculus	*Thinking in terms of functions*
Basic Calculus	*Understanding rates of change*

TEAMS problems will typically be more lengthy and involved than these examples, but the following problems represent an example of typical math that may be found in the competition.

(solutions are given in red)

Given: $v_f = v_i + a\,t$ and $s_f = s_i + v_i\,t + ½\,a\,t^2$

1. Cedar Point's Millennium Force accelerates from 10mph (at the top of the hill) to 93 mph (bottom of the hill) in 4.5 seconds. Assuming the acceleration is constant, find (a) the acceleration (in ft/sec^2) and (b) the distance traveled in meters.

$v_f = v_i + a\,t$ — 10 mph = 14.67 ft/sec
136.4 ft/sec = 14.67 ft/sec + a (4.5sec) — 93 mph = 136.4 ft/sec
a = **27.05 ft/s^2**

$s_f = s_i + v_i\,t + ½\,a\,t^2$ = 0 + 14.67(4.5) + ½ (27.05)(4.5^2) = 340 ft = **103.6 m**

2. The designers decide to modify the rise to become the tallest roller coaster in the world. Using the acceleration from #1, find the final velocity (in mph) if the drop height is increased to 128 meters.

Find t: $s_f = s_i + v_i\,t + ½\,a\,t^2$
420 ft = 14.67t + ½ (27.05)t^2 >> 13.525t^2 + 14.67t – 420 = 0 >> t = 5.06 sec

$v_f = v_i + a\,t$ = 14.67 + (27.05)(5.06) = 151.43 ft/sec = **103 mph**

The total energy (E) of a projectile is the sum of its kinetic and potential energy:

$$E = \tfrac{1}{2} m V^2 + mgz \qquad (2)$$

where m is the mass of the projectile, V is its speed, g is the gravitational constant, and z is its height above some datum point $z_0 = 0$. If we neglect air friction, then the energy of the projectile is constant. Use this information to solve the following problems.

3. Consider a 5.0 kg object, dropped from rest (V = 0 at time t = 0). What will the speed of the object be (in m/s) after it has fallen 10.0 ft? Use a gravitational constant of 32.0 ft/s^2.

We can calculate the energy at t = 0:

$$E = \tfrac{1}{2}mV^2 + mgz = \tfrac{1}{2}m(0m/s)^2 + mg(0\,ft) = 0$$

Now the energy at z = -10ft:

$$\begin{aligned}
E &= \tfrac{1}{2}mV^2 + mgz \\
0 &= \tfrac{1}{2}mV^2 + mgz \\
V^2 &= -2gz \\
&= -2(32\,ft/s^2)(-10\,ft) \\
&= 640\,ft^2/s^2 \\
&= (25.3\,ft/s)\left(\frac{1m}{3.2808\,ft}\right)
\end{aligned}$$

$$\boxed{V = 7.7m/s}$$

4. If a 17.45 lb_m ball is thrown upward with an initial speed of 21.53 ft/s, how high (in ft) will it go above its initial point? Use a gravitational constant of 9.81 m/s^2.

m_{ball} = 7.45lb (0.4536kg/lb) = 3.52 kg   21.53ft/sec = 14.7 m/sec

energy at t=0: $E = \tfrac{1}{2}mV^2 + mgz$

= 0.5 (3.52kg)(7.53m/sec)^2 + 0 = 100 k·gm^2/s^2

Now, Z when V=0:

100 k·gm^2/s^2 = 0 + 3.52kg (9.81m/s^2) z

z = 100 k·gm^2/s^2 / [3.52kg (9.81m/s^2)] = 9.5 **ft**