The final launch of NASA’s space shuttle Endeavor (STS-134) occurred on May 16, 2011 at 8:56:28 a.m. EDT from launch pad 39A. The image above was taken 17 seconds after launch. See the launch video on YouTube at http://www.youtube.com/watch?v=ShRa2RG2KDI

This historic flight was watched by millions of people world-wide. The table above shows the speed and altitude data for the first 20 seconds after launch. The combined fuel tanks and Orbiter had a mass of 2,052,443 kg at launch. The launch gantry had a height of 106 meters.

**Problem 1** - Plot the altitude of Endeavor Shuttle versus time during the first 20 seconds of launch.

**Problem 2** - Plot the speed of the Endeavor Shuttle versus time during the first 20 seconds of launch.

**Problem 3** - About what is the speed of the Shuttle when it clears the gantry in A) meters/sec/ B) miles per hour?

**Problem 4** - What is the average acceleration of the shuttle during its first 20 seconds of flight?

Space Math http://spacemath.gsfc.nasa.gov
**Problem 1** - Plot the altitude of the Endeavor Shuttle versus time during the first 20 seconds of launch.

![Graph of Altitude vs. Time](image1)

**Problem 2** - Plot the speed of the Endeavor Shuttle versus time during the first 20 seconds of launch.

![Graph of Speed vs. Time](image2)

**Problem 3** - About what is the speed of the Shuttle when it clears the gantry in A) meters/sec/ B) miles per hour?

Answer: A) The gantry height is 106 meters, so from Problem 1, we estimate that this speed occurred about 6 seconds after launch. The speed at this time is about $S=36 \text{ m/s}$. B) $S = 36 \text{ m/s} \times (3600 \text{ s/1 hr}) \times (1 \text{ km/1000 meters}) \times (0.62 \text{ miles/km}) = 80 \text{ mph}$.

**Problem 4** - What is the average acceleration of the shuttle during its first 20 seconds of flight?

Answer: Acceleration = velocity change/time, so between $T=0$ and $T = 20$ sec, the speed changed from 0 m/s to 148 m/s so $A = 148/20 \text{ sec} = 7.4 \text{ m/sec/sec}$. 