Describing Motion

- **Goal: To know the position and velocity of an object at all times**

Describing Motion

- **Scalar quantities are completely described by a number (magnitude) and unit**
- **One piece of information, direction is not relevant**
- **Distance, speed, kinetic energy, temperature**

Describing Motion

- Vector quantities are described by a size (number, magnitude) and a direction
- Three pieces of information (number unit and direction), direction is important
- Displacement, velocity, force, acceleration, electric and magnetic fields

Describing Motion

- Distance is a scalar quantity measuring the total length of the complete path traveled by the object (odometer)
- Displacement is a vector quantity representing the change in position of an object

Comments on Velocity

- In a Position Vs Time graph, the instantaneous velocity at any point is the slope of the graph (a tangent to the graph) at that point.
- The derivative of a function is the slope of the function.
- Instantaneous velocity is the derivative of position as a function of time.

Thus Far …

Speed

$$v_{avg} = \frac{d}{\Delta t}$$

Velocity (1D)

$$\vec{v} = v_{x\,avg}\hat{i} = \frac{\Delta x}{\Delta t}\hat{i}$$

$$\vec{v} = v_x\hat{i} = \lim_{\Delta t \to 0}\frac{\Delta x}{\Delta t}\hat{i} = \frac{dx}{dt}\hat{i}$$

Speed is the magnitude of the instantaneous velocity

Velocity (2D)

$$\vec{v}_{avg} = \frac{\Delta x}{\Delta t}\hat{i} + \frac{\Delta y}{\Delta t}\hat{j}$$

Acceleration (1D)

$$\vec{a}_{avg} = \frac{\Delta \vec{v}}{\Delta t}$$

Acceleration occurs when there is a change in velocity. This may result from a change in speed or a change in direction.

$$\vec{a}_{avg} = a_{avgx}\hat{i} = \frac{\Delta v_x}{\Delta t}\hat{i} = \frac{v_{xf} - v_{xi}}{t_f - t_i}\hat{i}$$

Average acceleration in the x direction only (1D)

$$a_x = \lim_{\Delta t \to 0} \frac{\Delta v_x}{\Delta t} = \frac{dv_x}{dt}$$

Instantaneous acceleration

Note: Average acceleration equals instantaneous acceleration for uniform acceleration.

Note: Slope of the velocity versus time graph (1D motion) is the acceleration

Average Acceleration Problem

A plane lands with a velocity of 72 m/s moving to the right. The plane slows to rest in 29 seconds. Determin the average acceleration of the plane.

One Dimensional Motion
Under Uniform Acceleration

Fundamental Equations

$$v_{xavg} = \frac{v_f + v_i}{2}$$

True for Uniform Acceleration Only

$$v_{xavg} = \frac{x_f - x_i}{t}$$

Δt = t if we start the stop watch at t_i=0

$$a_x = \frac{v_f - v_i}{t}$$

Average acceleration equals instantaneous acceleration for uniform acceleration

One Dimensional Motion Under Uniform Acceleration

$$v_{xf} = v_{xi} + a_x t$$

$$x_f = x_i + \frac{1}{2}(v_{xf} + v_{xi})t$$

$$x_f = x_i + v_{xi}t + \frac{1}{2}(a_x)t^2$$

$$v_{xf}^2 = v_{xi}^2 + 2a_x(x_f - x_i)$$

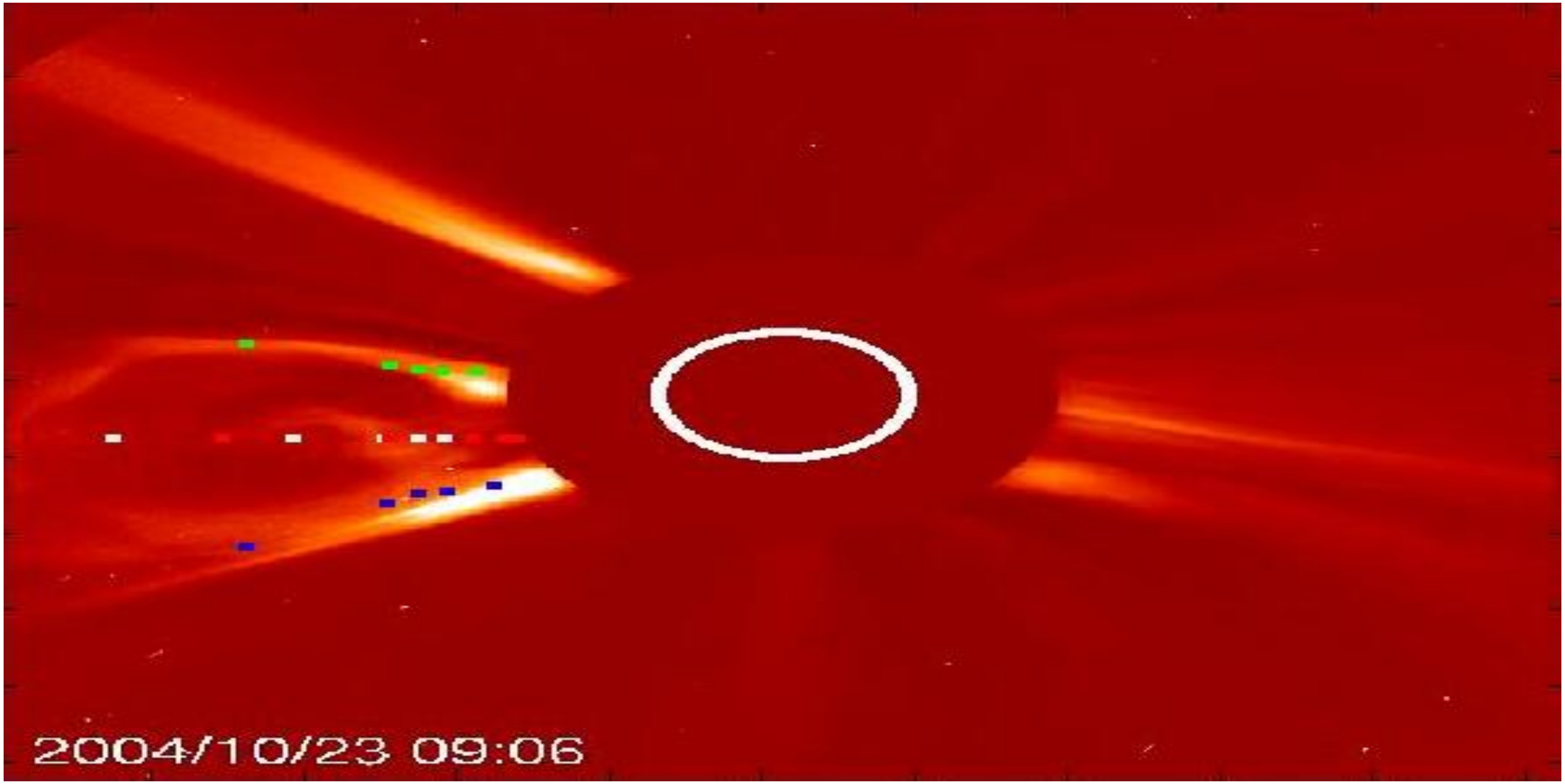
Solve any constant acceleration problem using these formula

Uniform Acceleration Problem

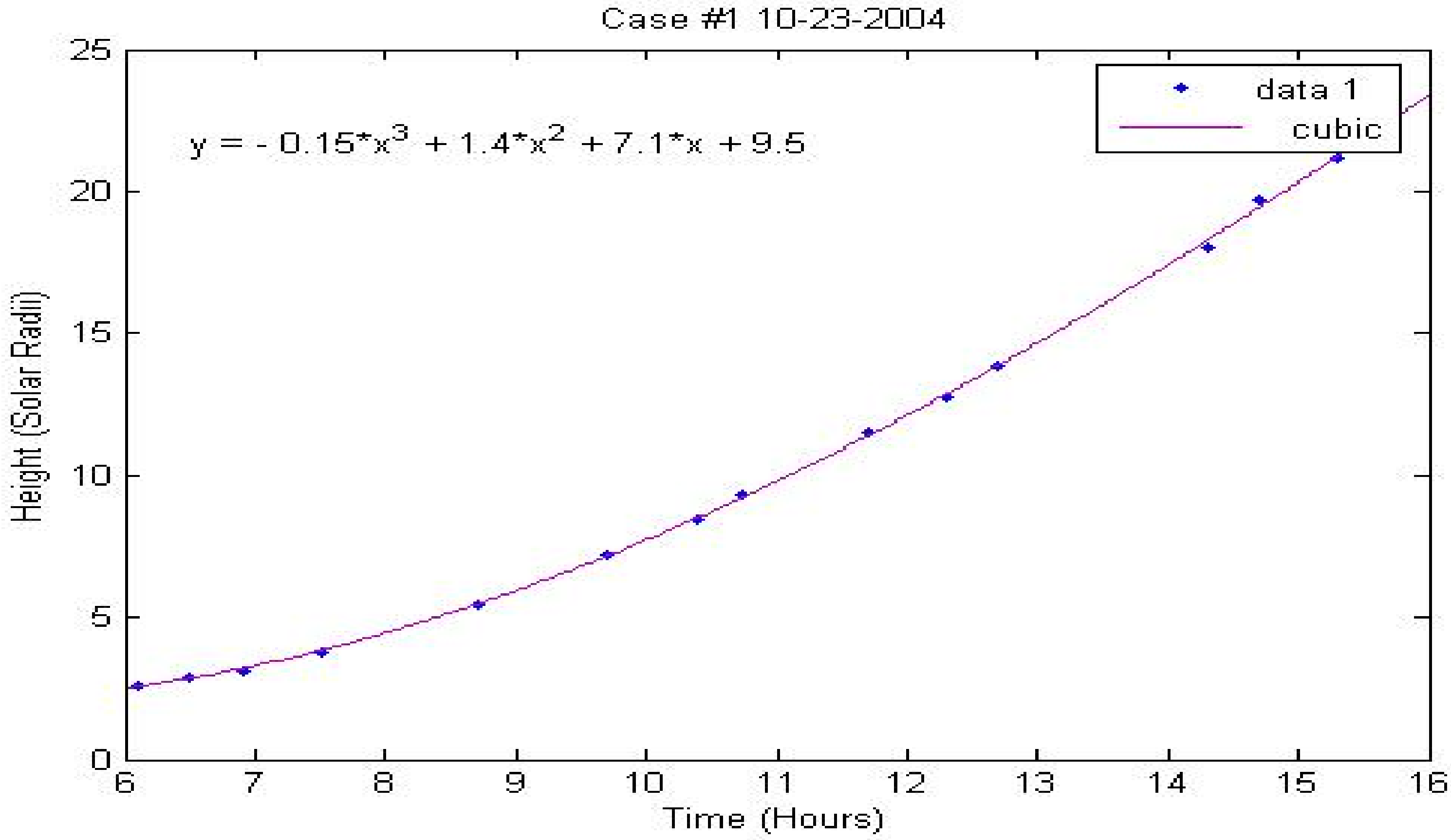
Small Plane Airport. Planes must achieve a speed of 27.8 m/s and can accelerate at 2.00 m/s^2 . What is the minimum length the runway must have?

One Dimensional Motion
Under Uniform Acceleration

Small Plane Airport. Planes must achieve a speed of 27.8 m/s to take off and can accelerate at 2.00 m/s^2. What is the minimum length the runway must be?



The colored points seen on the C2 image are where the data points were taken for thickness of the loop and the width of the loop.



- This plot shows the distance the case one CME travels (from the sun’s center) as a function of time
- From this graph the velocity and acceleration can be calculated.

Coronal Mass Ejection

A coronal mass ejection leaves the sun with a velocity of 1.37 x 10^6 m/s and accelerates out into space at 75.2 m/s^2. How long does the CME take to reach the orbit of Mercury 5.9 x 10^9 m away?