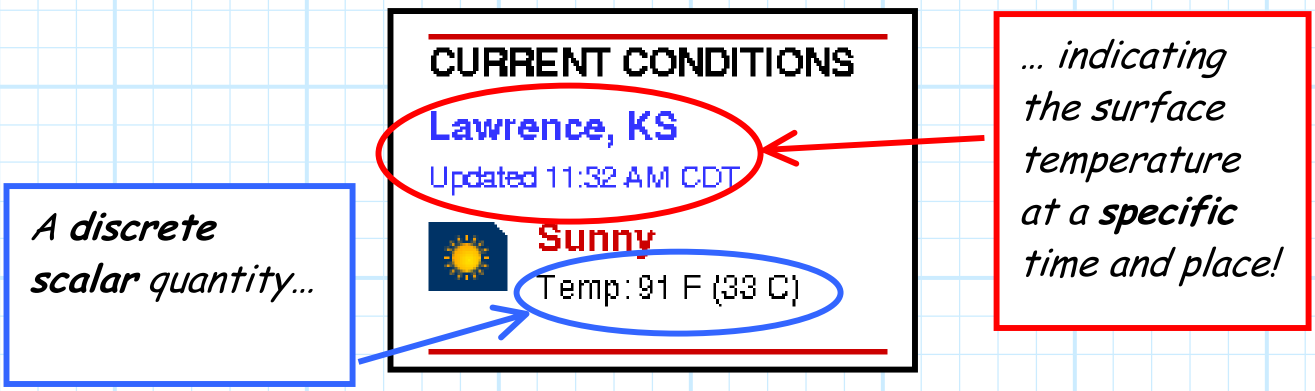
Examples of Physical Quantities

A. Discrete Scalar Quantities can be described with a single **numeric** value. Examples include:

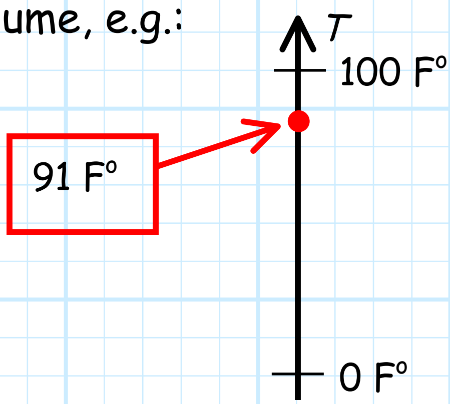
1) My **height** (~ 6 ft.).

2) The weight of your text book (~ 1.0 lbs.)

3) The **surface temperature** of a **specific** location at a **specific** time.



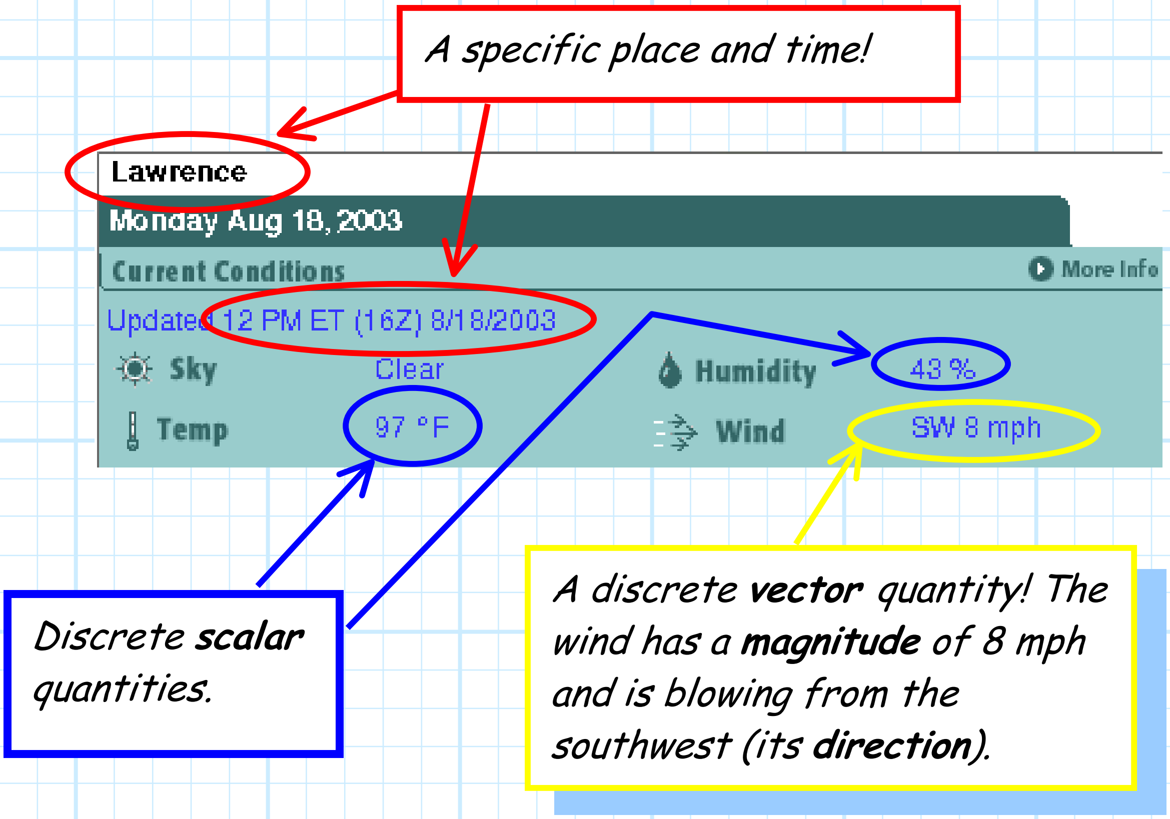
Graphically, a discrete scalar quantity can be indicated as a **point** on a line, surface or volume, e.g.:



B. **Discrete Vector Quantities** must be described with both a **magnitude** and a **direction**. Examples include:

1) The **force** I am exerting on the floor (180 lbs. +++, in a **direction** toward the center of the earth).

2) The wind **velocity** of a **specific** location at a **specific** time.



We will find that a discrete vector can be **graphically** represented as an **arrow**:

wherein the length of the arrow is proportional to the **magnitude** and the orientation indicates **direction**.

C. Scalar Fields are quantities that must be described as one function of (typically) **space** and/or **time**. For example:

1) My weight as a **function of time**.

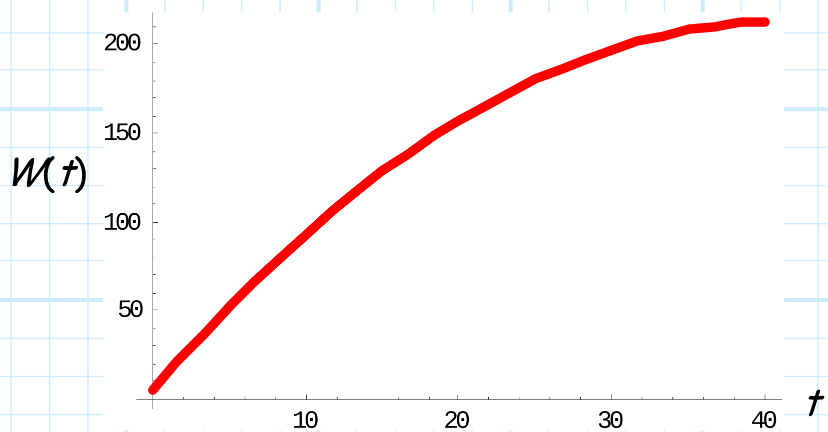
Note that we **cannot** specify this as a **single numerical value**, as my weight has **changed** significantly over the course of my life!

Instead, we must use a **function** of time to describe my weight:

$$W(t) = 5.2 + 10t - 0.12\,t^2 \quad \text{lbs.}$$

where t is my age in years.

We can likewise **graphically** represent this scalar field by plotting the function $W(t)$:



Note that we **can** use this scalar field to determine **discrete** scalar values! For example, say we wish to determine my weight **at birth**. This is a discrete scalar value—it can be expressed numerically:

$$W(t=0) = 5.2 + 10(0) - 0.12\,(0)^2$$
$$= 5.2 \text{ lbs.}$$

Why I'm ***always*** *hungry!*

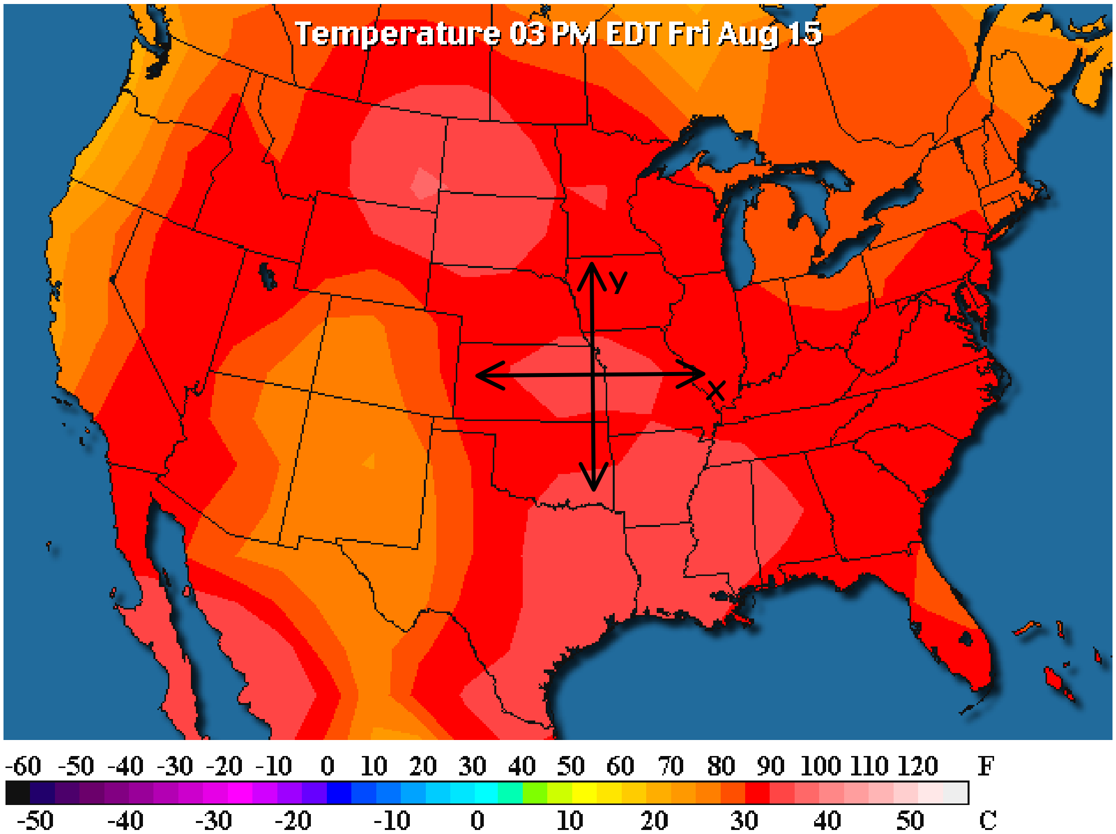
Note this **discrete** scalar value indicates my weight at a **specific** time (t=0). We likewise could determine my **current** weight (a **discrete** scalar value) by evaluating the scalar field $W(t)$ at t=44 (Doh!).

2) The current surface temperature across the **entire** the U.S.

Again, this quantity **cannot** be specified with a single numeric value. Instead, we must specify temperature as a **function** of position (location) on the surface of the U.S. , e.g.:

$$T(x,y) = 80.0 + 0.1x - 0.2y + 0.003xy + ...$$

where x and y are Cartesian coordinates that specify a **point** in the U.S. Often, we find it useful to **plot** this function:

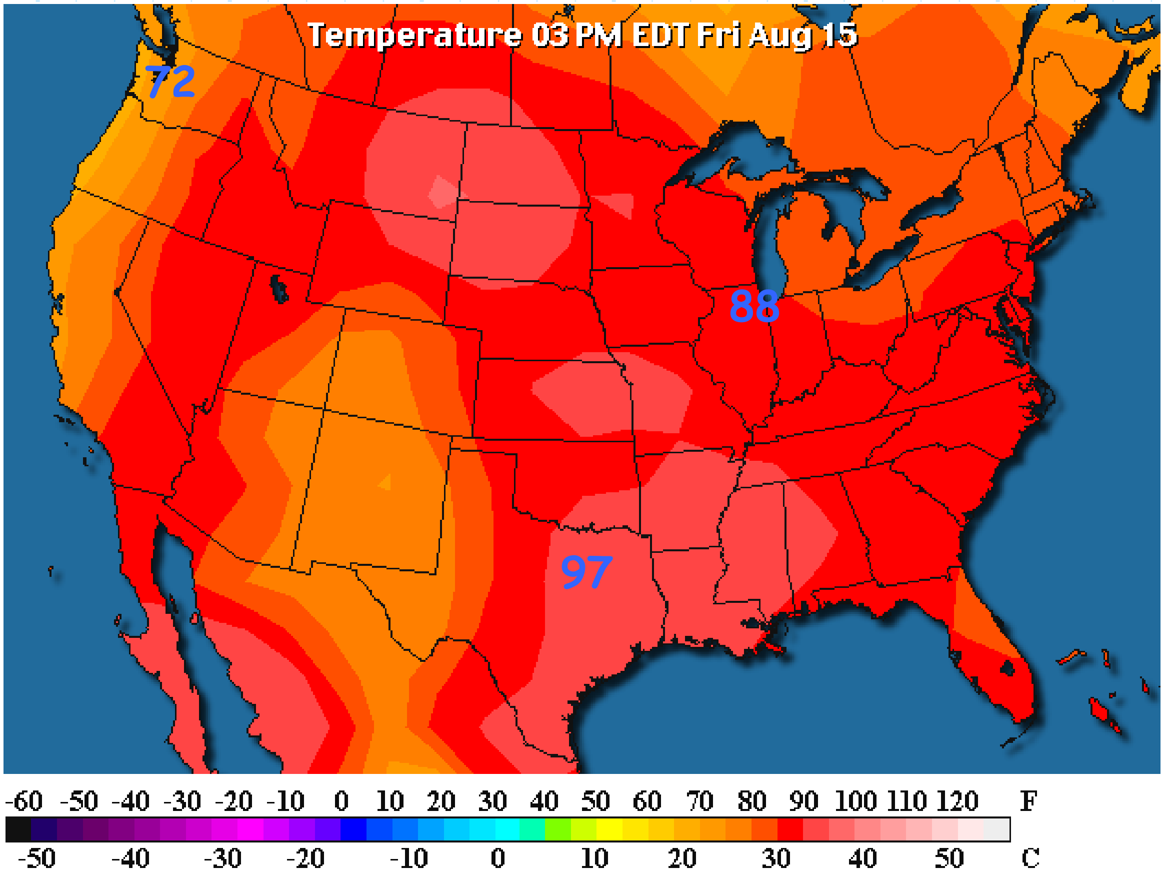


Again, we can use this scalar **field** to determine **discrete** scalar values—we must simply indicate a **specific** location (point) in the U.S. For example:

$$T(x,y = Seattle, WA) = 72\ F^\circ$$

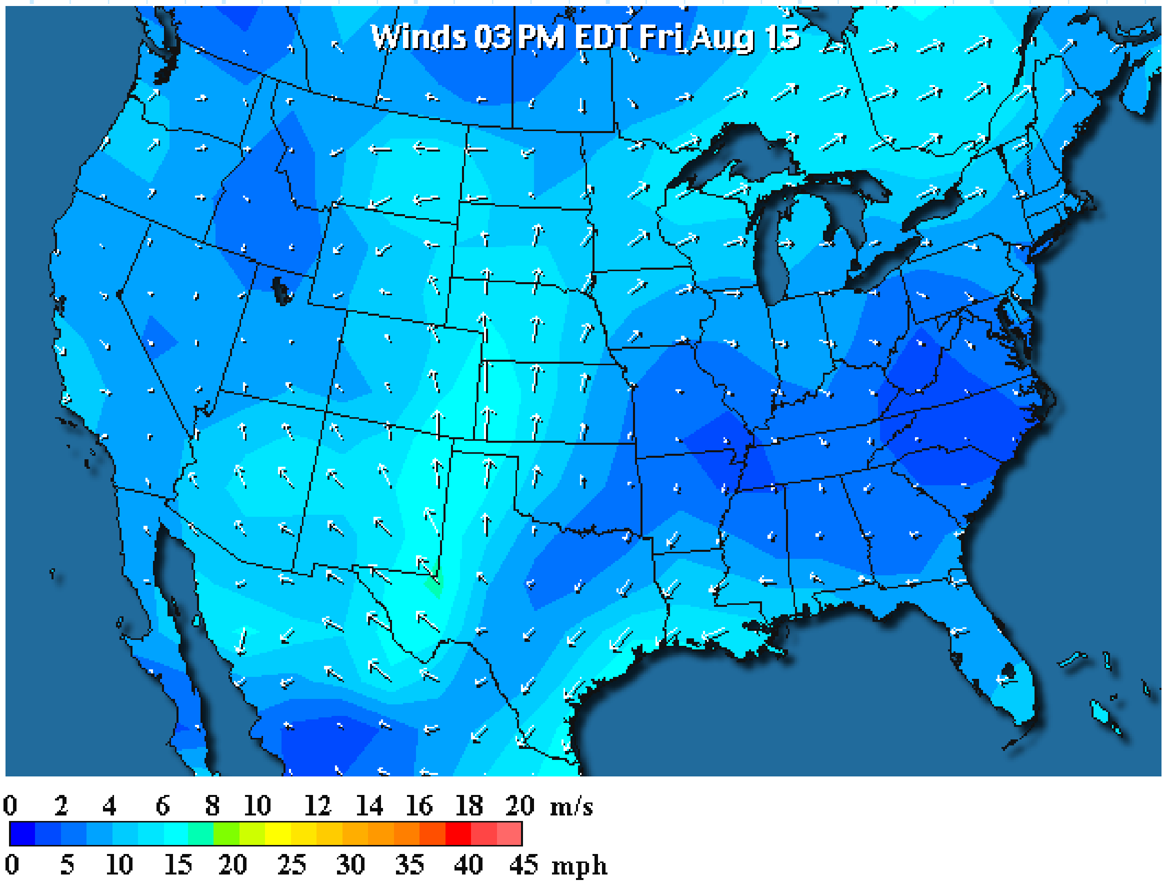
$$T(x,y = Dallas, TX) = 97\ F^\circ$$

$$T(x,y = Chicago, IL) = 88\ F^\circ$$



D. **Vector Fields** are vector quantities that must be described as a function of (typically) space and/or time. Note that this means **both** the magnitude and direction of vector quantity are a function of time and/or space!

An example of a vector field is the **surface wind velocity** across the entire U.S. Again, it is obvious that we **cannot** express this as a **discrete** vector quantity, as **both** the magnitude and direction of the surface wind will **vary** as a function of location (x,y):



We can **mathematically** describe vector fields using **vector algebraic** notation. For example, the wind velocity across the US might be described as:

$$\mathbf{v}(x,y) = x^2 y\, \hat{a}_x + (2x - y^2)\, \hat{a}_y$$

Don't worry! You will learn what this vector field expression means in the coming weeks.