

There are three systems in nature – Static, dynamic and hybrid. An example of dynamic systems is say, an apple fruit growing in an apple tree from flower. Once it matures, it becomes static – does not grow any further. Then again, it's contents become dynamic until it becomes a fruit and fall from tree.



Figure 1. From flower to falling fruit of Apples

Birth of humans, animals, Insects etc., all go through a dynamic growing state and at maturity reach their normal size

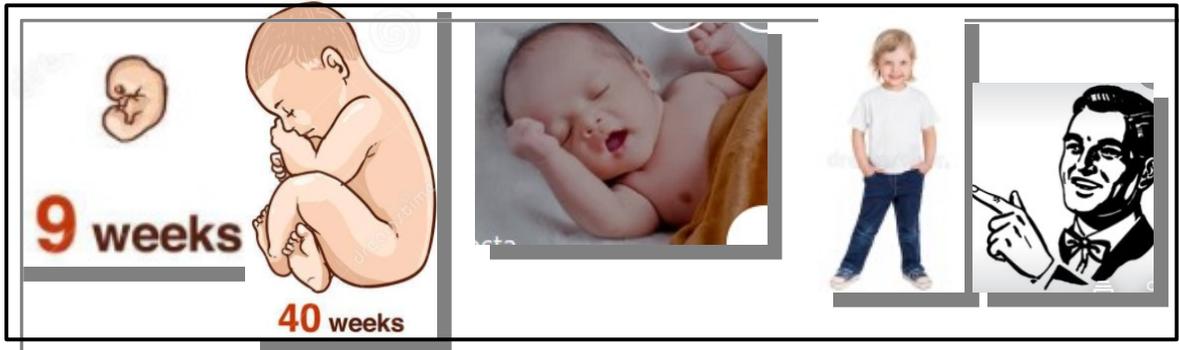


Figure 2 Dynamic growth from fetus to an adult human being

So, the height, weight and other attributes(features, properties) are dynamic in their value. In general increasing with age. Once the grow is over or at any stage when similar human beings are studies, we count them. Why? They have a proper name – baby, child,adult...- and thus can be numerically counted. This is numerically countable objects of the same kind is technically called “arithmetic”. However, if we group them such as, males, boys and gender neutral, then it becomes Algebra. Why? They have a group name such as males, females and binary(or nogender). Thus, when arithmetically say, 10 boys, 5 girls and 2 nongenders, then the total is not 17 as in arithmetic , rather $10B+5G+2N$ (B: boys,G: Girls, N: nongender), thus Total = $10B+5G+2N$ (which is different from Total of all= 17).

Thus, it appears that static systems involve counting and arithmetic operations such as addition, subtraction and fraction(ratio) etc. However multiplication is a shorthand for successive addition, thus even though is used in arithmetic operation, it is not a basic arithmetic operation.

If the object is not solid such as, fluid, gases, waves and so on, simple arithmetic operation of counting can not be used. Why? The

measurement does not give absolute numerical value given as in arithmetic operation. Rather the value involves error in measurement. Thus, approximate measurements are involved. Liter, flow, etc., are measured with lower and upper error limits are also stated with the measurements.

For example, when there are three boys found due to counting, “three” is arithmetic result and does not change. So, we normally don’t say approximately three boys (or girls). But in nonliving thing, if we can divide them we use fraction such as, half a loaf of bread, half a banana and so on. The error is ignored as it may be negligible for a person.

Now we buy say cooking oil. The bottle in which it comes says” 500 ml” container. This is an approximation between say, 497 to 502 ml. Similarly, the speed of a vehicle may be between 54 and 56 km/hour, but a speedometer gauge will say 55km/hr which is an approximation only. That is there is a margin of error either at the lower level (below 55 km/hr) or the upper level (above 55 km/hr). We accept the average of 55 km/hr as though it is an arithmetic value(numerical measure).

How do we show the static arithmetic measurement and dynamic arithmetic measurement using symbols?

For the arithmetic totaling (addition) is technically called “Summation”. So, the capital letter “S” is used as a special character in arithmetic operation. There is also a Greek letter(mathematics alphabet uses Greek, Latin and other special characters, similar to a natural language like English, but no one has defined a mathematical language say M with all its alphabets, operations, sentences and so on!) The Greek letter is Σ (spelled as Sigma and the first sound in it is S). Thus, while an ordinary person uses :

Total cost = Cost of 5 Apples + Cost of 4 Bananas + Cost of 2 Coconuts
a mathematician may write this either as:

$S = C_1 A + C_2 B + C_3 C_0$ where C_1, C_2, C_3 are coefficient(numerical quantities) and A,B, C_0 are variables or proper names. We do not teach arithmetic like this way from the beginning and may be on the 9th grade level introduce these notations.

The above summation can also be alternatively written as follows:

$$\Sigma \text{ costs} = C_1 + C_2 + C_3$$

are if the values are stored in a table such as:

Items	Apple Cost	Banana cost	Coconut cost
Unit cost	1.25	0.50	6.50
Item purchased	5	4	2
Total Cost ? =	1.25 x 5 +	0.50 x 4 +	6.60 x 2

We do not teach this tabular format or Matrix unless one takes accounting or computer programming or Engineering at the high school level.

In this tabular format, $\Sigma = (\text{Row-2,2} \times \text{Row 3,2}) + (\text{Row-2,3} \times \text{Row 3,3}) + (\text{Row-2,4} \times \text{Row 3,4})$

This says, add the (row-2 column-2 value) x (row-2 column-2 value) =....

$$= 1.25 \times 5 + \dots$$

In the matrix, the rows are horizontal and columns are vertical and the left most are descriptive identifier for each row.

In general, 3rd row column-2 will be $1.25 \times 5 = 6.25$, then $0.50 \times 4 = 6$, then $6.0 \times 2 = 7.20$, and the total is sum of them, which is 19.45. Thus, the

Total cost = 19.45.

Now to show how to add dynamic quantities, there is only one symbol is used. Since S is the static summation symbol, if you stretch the S vertically, it will appear as \int . Then we write the lower measurement value (lower limit) at the bottom of the sign and the upper estimate or upper limit at the top of the symbol as follows:

$$\text{Speed} = \int_{54}^{56} 55 \text{ km/hr}$$

Note this is not average but says, the speed may be as low as 54 km/hr or as high as 56 km/hr, but I do not have fraction in my display so I am showing the middle value as a possible speed. This is why, when speeding ticket by police is given they allow between 5% to 10% of the posted speed limit as allowable since their scanning device has the same problem too.

Since this is not an introduction to the Calculus class, rather a simple way to understand that the dynamic measurements are known as integrated values(integration), where as in statistic systems they are known as summation or simply arithmetic addition.

Our next general question is what is differentiation? Let us go back to our Apple and fetus to adult figure. After maturing, then in Apple the ripening process takes place which converts the sour taste into a sugary sweet taste. Thus it takes sum time to make this change? This is called rate of change of taste with respect to time. Symbolically

Δ (small change in time) t increase and the sweetness index say k, how they are related.?

Since time can not be changed which is dynamic, we rephrase this question is, given time is changing Δ unit such as Δt , how much Δk changes.? Alternatively we can state, what is the rate of change in taste k, with respect to the incremental time Δt ? We are taught this can be written as :

$$\Delta k / \Delta t = ?$$

That is if time ‘t’ changes by some unit, how much will the sweetness increase in the apply Δk ?

So, via experimenting they may comeback with an answer (just a guess)

that is , for every hour, the sweetness of Apple increases by say 0.0025%. Or say it takes about 2 days to ripe. So, they will say , put the apple in a paper back and the ethylene it releases will ripen it.

Now, take for human example. It is said that for every pound (or KG) weight – fat increase in an adult, increases the blood pressure. Without worrying about the details, we can state,

$$\text{The rate of BP increase} / \Delta \text{ kg of fat} = ?$$

Here the rate of change of BP per unit increase of body fat (due to excess caloric intake) for an average person is what?

Thus, we can state approximately what is the differentiation? It is a mathematical measure of two or more dependent factors related to some uniform rate of increment of a reference factor. Here, the kg of fat increase affects the rate of BP, thus BP is a dependent feature on the kg of fat.

Thus. when you have dynamic systems say, velocity of wind and the amount of sand it will spread, you need dependent ratio analysis. *That is the rate at which a variable changes either in space or time or both affects or influences the other related dependent variables is the study of differential equation. That is, it is related to dynamic system in general.*

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