Hartree's differential analyser
– an electromechanical computer

The speaker (Charles Lindsey) has prepared his own reference sheet.

Area We all know that the area of a rectangle is *base*×*height*, and if it is a bit more complicated like a triangle, then it is *(base*×*height)/2*. But what if it is an arbitrary blob? Well, it would help if you could give me a graph of it, or better a formula which could be plotted as a graph. Then the question becomes "what is the area underneath this graph".

Integration The process of calculating the area under a graph. Essentially, it is still *base*×*height*, but the problem is that the height is changing as fast as you are trying to multiply by it. Sometimes, if the graph follows a nice simple formula, you can work out a formula for the corresponding area. But sometimes, even a quite innocent-looking formula has no known formula for the area; and then you need a machine to grind out the answer (or lots of paper and ink) and even then the answer will never be exactly correct.

Example Consider a train, and a graph showing its velocity at various times (perhaps it is climbing up Shap on its way to Carlisle, and getting slower and slower). The area underneath the graph then represents the distance travelled up to that point in time. In other words, if you integrate a graph of velocity against time, you get a graph of distance against time.

Differentiation The opposite of integration. You start with a graph of distance against time, and obtain a graph of velocity against time. When learning calculus, you are taught differentiation first, because there are nice rules for doing it, so you don't need a machine to do the job.

Differential equations Equations that include terms which have been differentiated (and maybe differentiated several times). Many scientific and engineering problems can be expressed as differential equations, so finding solutions for them is very important.

(cont.) If you are lucky, you can find a nice simple formula which represents the result. If you are unlucky, there just does not exist such a formula; then you have to turn the thing inside out (I suppose you might then call it an integral equation, but mathematicians don't seem to use that term), and then you need a machine to grind out the answer (or lots of paper and ink) and even then the answer will never be exactly correct. And essentially, the machine just has to do integration (except that there may be several integrations all going on at the same time).

Differential analyser A machine for grinding out such answers (or, to put it more politely, for integrating its way through the equations). The first such machines were purely mechanical (like the one built for Professor Hartree); then came electronic ones, and nowadays you use a digital computer for the job.

Integrating disc and wheel A rotating horizontal disc (turntable) on which a small knife-edged wheel rests. The rotating disc drives the wheel by friction. The vertical axis of the turntable is connected to the *x*-input. The distance of the point of contact of the wheel on the turntable from the centre of the disc is connected to the *y*-input. The output is the result of integrating the graph of *x* against *y*. There is just one snag. We want to take the output and use it as input to other integrators, and the friction between the two wheels just cannot provide enough power to do this.

Torque amplifier A mechanical device that increases the output torque of the rotating shaft from the integrator wheel.

Input table The place where information about the differential equation is transmitted to the machine, by a stylus tracing out the shape of a pre-plotted graph. For example, a graph showing the gradient at each point on the way up Shap.

Output table The place where the solution to the equation is drawn as a continuous curve by a pen on paper.

Next SciBar: 10 November 2014, Artificial photosynthesis – a sustainable way of powering the planet? Time: 6.30pm as usual.