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115. The Number of Ways of Writing "Tot tibi sunt dotes, Virgo, quot sidera coelo," without Disobeying the Laws of Metre, Caesura Excepted

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Consequently

$$\frac{\xi^2}{r_1^2}(\rho_1^2 - r_1^2) - \frac{\xi\eta}{r_1 r_2}(r_1^2 + r_2^2 - r_3^2) + \frac{\eta^2}{r_2^2}(\rho_1^2 - r_2^2) = 0$$

represents two lines which are coincident with the major axis, whose equation therefore is

$$2 \frac{\xi}{r_1}(\rho_1^2 - r_1^2) - \frac{\eta}{r_2}(r_1^2 + r_2^2 - r_3^2) = 0,$$

$$\text{or } 2(\rho_1^2 - r_1^2)[\nabla]_{c=-(gx+fy)} + (ab - h^2)^{\frac{3}{2}}(r_1^2 + r_2^2 - r_3^2)(xy_1 - x_1y) = 0.$$

Similarly the minor axis is

$$2(r_1^2 - \rho_2^2)[\nabla]_{c=-(gx+fy)} - (ab - h^2)^{\frac{3}{2}}(r_1^2 + r_2^2 - r_3^2)(xy_1 - x_1y) = 0.$$

Similar results may be obtained for the hyperbola, and its asymptotes will be

$$\begin{vmatrix} x, & y, & 1 \\ -f, & g, & \pm\sqrt{h^2 - ab} \\ bg - fh, & af - gh, & h^2 - ab \end{vmatrix} = 0,$$

except in the case when one asymptote passes through the origin.

115. [J. 1. a.] *The number of ways of writing "Tot tibi sunt dotes, Virgo, quot sidera coelo," without disobeying the laws of metre, caesura excepted (v. No. 35, p. 216, Netto's "Lehrbuch der Combinatorik").*

Let  $\alpha$  denote a monosyllable,  $\beta$  a dissyllable, and  $\gamma$  the alternative of *sidera* or *tibi*.

Then we have  $\alpha\alpha\alpha\beta\beta\gamma\gamma$ .

I. Let the verse end with  $\gamma\beta$ . The  $\beta$  can be chosen in three ways; the  $\gamma$  in two ways. It remains to arrange the remaining words  $\alpha\alpha\alpha\beta\beta\gamma$ .

These can be arranged in 6 orders, of which exactly half will be valid. For if  $\gamma = \textit{sidera}$  those arrangements will be valid which have an even number of  $\alpha$ 's somewhere before the  $\gamma$ ; and if  $\gamma = \textit{tibi}$  those will be valid which have an odd number of  $\alpha$ 's somewhere before the  $\gamma$ .

Hence choice  $= 3 \times 2 \times 6 \div 2 = 2160$ .

II. Let the verse end with  $\gamma\alpha\alpha$ . The  $\alpha\alpha$  can be chosen in six ways, the  $\gamma$  in two ways. It remains to arrange the remaining five words. And, precisely as before, half of the 6 arrangements will be valid.

Hence choice  $= 6 \times 2 \times 6 \div 2 = 720$ .

Therefore the total number of arrangements is  $2160 + 720 = 2880$ .

If it were required to have caesura in the third foot the number of arrangements would be reduced to 1620.

W. ALLEN WHITWORTH.

The words in the line give the syllabic arrangement

$$\begin{array}{c|c|c|c|c|c} \text{---} \text{---} \text{---} & \text{---} \text{---} \text{---} & \text{---} \text{---} \text{---} & \text{---} \text{---} \text{---} & \text{---} \text{---} \text{---} & \text{---} \text{---} \text{---} \\ \text{or} & \text{or} & \text{or} & \text{or} & & \\ \text{---} \text{---} \text{---} & \text{---} \text{---} \text{---} & \text{---} \text{---} \text{---} & \text{---} \text{---} \text{---} & \text{---} \text{---} \text{---} & \text{---} \text{---} \text{---} \end{array}$$

I. Line ends in *sidera* followed by a dissyllable (not *tibi*). The dissyllable may be chosen in three ways: for each of the 6 permutations of the remaining six words we have to reject those in which *tibi* is first or third in order of the four words *tot tibi sunt quot*, i.e. half the whole number.

I. therefore gives  $\frac{3 \times 6}{2}$  arrangements.

II. Line ends in *sidera* followed by two monosyllables. The sixth foot can be formed in six ways: for each case, from the whole number of permu-

tations of the remaining five words, we have to reject all in which *tibi* comes earlier than the remaining monosyllable—half of the whole number.

∴ II. gives  $\frac{6|5}{2}$  arrangements.

III. Line ends in *tibi* followed by dissyllable: from the possible permutations of the words we have to reject those in which *sidera* comes second or fourth of the words *tot sunt quot sidera*.

∴ III., like I., gives  $\frac{3|6}{2}$  arrangements.

IV. Line ends in *tibi* followed by two monosyllables: from possible permutations reject those in which a monosyllable comes earlier than *sidera*.

∴ IV. gives  $\frac{6|5}{2}$  arrangements.

∴ Whole number of arrangements is  $2\left(\frac{3|6}{2} + \frac{|6}{2}\right) = 4|6 = 2880$ .

W. E. HARTLEY.

#### 116. [X. 4. b. a.] *Note on the Graphical Solution of Quadratics.*

The general quadratic,  $ax^2 + bx = c$ , is satisfied by the values of  $x$  which are common to the equations  $y = x^2$ ,  $ay + bx = c$ .

The first of these represents a fixed parabola which is easily graphed for permanent use, and the second represents a variable straight line which is easily graphed for particular values of  $a, b, c$ . Thus the only requisites for approximating to the roots of a quadratic are the possession of a good printed, or accurately drawn, graph of the above parabola on squared paper and a little ingenuity in the manipulation of the straight line.

Two points only on the line  $ay + bx = c$  are wanted, and these are generally to be obtained by selecting simple integral values for  $x$  and  $y$ .

*E.g.*, convenient points on  $3y + 5x = 4$  would be  $\left. \begin{matrix} x=2 \\ y=-2 \end{matrix} \right\}, \left. \begin{matrix} x=-1 \\ y=3 \end{matrix} \right\}$ .

In practice it will be found convenient not to draw the line, but to place the straight edge of a sheet of paper on the points selected (which are usually two of the corners already marked on the squared paper), and prick on the parabola the points where it is cut by the straight edge.

In this way the original graph can, with care, be used for a considerable time. Of course any parabola would do, but  $y = x^2$  has the additional merit of providing a rough table of squares and square roots.

In a similar way the graph of  $y = x^3$  can be used to get solutions to any cubic equation if the cubic be first thrown into the form  $x^3 + ax = b$ .

A. E. WYNNE.

[The reader may remember the semi-graphic solution of a quartic equation by Prof. G. B. Mathews in *Nature*, Nov. 16, 1899. In Mr. Hall's supplementary chapter on "Graphical Algebra" to Hall and Knight's elementary treatise (6d., Macmillan), we find: Plot the graphs of  $y = x^3 - 3x$ . Find the roots of  $x^3 - 3x = 0$ , with several similar questions, pp. 22, 23. W. J. G.]

## REVIEWS.

**Higher Mathematics for Students of Chemistry and Physics.** By J. W. MELLOR, D.Sc. (Longmans.)

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