



190. An Apparatus for Teaching Long Multiplication

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Source: *The Mathematical Gazette*, Vol. 3, No. 55 (Jan., 1906), pp. 278-280

Published by: [Mathematical Association](#)

Stable URL: <http://www.jstor.org/stable/3602092>

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The ratio of corresponding ordinates is indeterminate when $x=a$.
But, drawing the tangents AT_1AT_2 at A , we have

$$\begin{aligned}\frac{F(x)}{f(x)} &= \frac{P_1M}{P_2M} = \frac{P_1M}{T_1M} \cdot \frac{T_1M}{T_2M} \cdot \frac{T_2M}{P_2M} \\ &= \frac{P_1M}{T_1M} \cdot \frac{AM \tan T_1AM}{AM \tan T_2AM} \cdot \frac{T_2M}{P_2M}\end{aligned}$$

and therefore when AM diminishes without limit

$$\begin{aligned}\lim_{x=a} \frac{F(x)}{f(x)} &= 1 \times \frac{\tan T_1AM}{\tan T_2AM} \times 1 \\ &= \frac{F'(a)}{f'(a)}.\end{aligned}$$

The extension to the case where $F'(a)$ and $f'(a)$ both vanish is obvious.
C. S. JACKSON.

187. [J. 5.] *The Continuum.*

Readers of the *Gazette* may be interested to know that Professor E. V. Huntington has concluded his series of articles in the *Annals*, "Mathematics on the Continuum" and the "Transfinite Numbers." They form an *elementary* introduction to some of the problems so actively debated at the present time in the field of Cantor's *Mengenlehre*.
W. J. G.

188. [C. 1. e.] *Proof of Taylor's Theorem.*

$$\text{Let } R = f(z) - f(z-h) - hf'(z-h) - \frac{h^2}{2}f''(z-h) - \dots - \frac{h^n}{n!}f^{(n)}(z-h),$$

$$\text{then } \frac{dR}{dh} = \frac{h^n}{n!}f^{(n+1)}(z-h).$$

$$\text{Keeping } z \text{ constant, } R = \int \frac{h^n}{n!}f^{(n+1)}(z-h)dh + \text{const.}$$

But $R=0$, if $h=0$;

$$\therefore R = \int_0^h \frac{h^n}{n!}f^{(n+1)}(z-h)dh,$$

which can be transformed or discussed in the usual way. The only thing the student has to remember is to put z for $x+h$, and therefore $z-h$ for x in the usual formula.
G. H. BRYAN.

189. [K. 13. a.] The *Remarque Minuscule* (Note 167, *Gazette*, May 1905) occurred to me also in 1887, and has been set in Aberystwyth and University of Wales' Examinations. It is, however, probably older, and contained in Bellavite's striking theorem, viz. if $ABCD\dots, A'B'C'D'\dots$ be similar polygons inversely situated, and if $AA'BB'CC'$, etc., be divided at P, Q, R , etc., each in the ratio of the linear dimensions of the polygons, then P, Q, R , etc., lie in a straight line.

The following extension of simple proof by Vector methods. If P_1, P_2 be points in AA' such that $AP_1 \cdot AP_2 : A'P_1 \cdot A'P_2 :: AB^2 : A'B'^2$, and if BB' be divided at Q_1Q_2 similarly to AP_1P_2A' , then P_1Q_1, P_2Q_2 are equally inclined to $AB, A'B'$.
R. W. GENESE.

190. [V. 1. a.] *An apparatus for teaching long multiplication.*

I devised this, in the first instance, to enable my pupils to change from the old method (left to right) to the new (right to left), without confusion.

It consists essentially of a blackboard composed of four (or more) rectangular slats ($1\frac{1}{2} \times 15$ m.'s each) which slide in horizontal grooves. The local carpenter made mine for 12s. 6d.

The following examples will show the use of this device :

Name the slats, from the top one downwards, A, B, C, D .

On A write any number, say 2763.

Multiply by 7 ; write the result, 19341, on B so that the 4 is directly beneath A 's 6.

(1) Add. Verify, result is $A \times 8$. Note that (1) is "useless."

(2) Move slat B one place to the left. Add. Verify, result is $A \times 71$. Remove B . Multiply A by 70, adding in A concurrently. Thus, for 2763×71 we have :

"3". Write 3.

" $7 \times 3 = 21$, and 6 make 27." Write 7.

" $7 \times 6 = 42$, carry 2 ; 44, and 7 make 51." Write 1.

" $7 \times 7 = 49$, carry 5 ; 54, and 2 make 56." Write 6.

" $7 \times 2 = 14$, carry 5 ; 19." Write 19.

Answer, 196173.

Verify, 2763×71

$$\begin{array}{r} 19341 \\ \underline{196173} \end{array}$$

(3) Replace B ; move it one place to the right. Add. Verify, result is $A \times 17$. Remove B . Multiply A by 7, adding in $10A$ concurrently. Thus, for 2763×17 we have :

" $7 \times 3 = 21$." Write 1.

" $7 \times 6 = 42$, carry 2 ; 44, and 3 make 47." Write 7.

" $7 \times 7 = 49$, carry 4 ; 53, and 6 make 59." Write 9.

" $7 \times 2 = 14$, carry 5 ; 19, and 7 make 26." Write 6.

"Carry 2 ; 2, and 2 make 4." Write 4.

Answer, 46971.

Verify, 2763×17

$$\begin{array}{r} 19341 \\ \underline{46971} \end{array}$$

(4) Replace B . Extend (2) and (3) for multiplication by 701, 107, etc.

(5) Replace B . Multiply A by 2 ; write the result, 5526, on C so that the 6 is directly below A 's 3.

Add. Verify, result is $A \times 10$ (c).

Place slats successively in position for multiplication by 27, 72, 271, 721, 172, 127, 217, 712, 19, 91, 73, 37, 28, 82.

E.g. 2763×72 (a)

$$\begin{array}{r} 19341 \\ 5526 \\ \underline{198936} \end{array}$$

2763×721 (a)

$$\begin{array}{r} 19341 \\ 5526 \\ \underline{1992123} \end{array}$$

2763×127 (b)

$$\begin{array}{r} 19341 \\ 5526 \\ \underline{350901} \end{array}$$

2763×712 (a)

$$\begin{array}{r} 19341 \\ 5526 \\ \underline{1967256} \end{array}$$

2763×19 (c)

$$\begin{array}{r} 19341 \\ 5526 \\ \underline{52497} \end{array}$$

2763×28 (c)

$$\begin{array}{r} 19341 \\ 5526 \\ \underline{77364} \end{array}$$

Note that (a) are correct "form" and "useful," (b) is incorrect "form"—correct by interchanging B and C —and "useful," while (c) are "useless."

(6) Extend (5) for multiplication by 7021, etc., etc.

(7) Remove C . Move B one place to the left. Subtract A .

Thus

$$\begin{array}{r} 2763 \times (70 - 1) \\ 19341 \\ \underline{190647} \end{array}$$

Remove *B*. Multiply *A* by 70, subtracting *A* concurrently.

Thus, for $2763 \times (70 - 1)$ we have :

"3 from 10 leave 7. Carry minus 1." Write 7.

" $7 \times 3 = 21$, minus 1 ; 20. 6 from 20 leave 14." Write 4.

" $7 \times 6 = 42$, carry 1 ; 43. 7 from 43 leave 36." Write 6

" $7 \times 7 = 49$, carry 3 ; 52. 2 from 52 leave 50." Write 0.

" $7 \times 2 = 14$, carry 5 ; 19." Write 19.

Answer, 190647.

Verify, $\frac{2763 \times 69}{}$

$$\begin{array}{r} 16578 \\ 24867 \\ \hline 190647 \end{array}$$

Note that (7) is harder than (2)-(6). Dull boys fail to grasp it, though they easily comprehend the rest of the system.

The board is also useful for the teaching of approximations and contracted (or Italian) long division.

F. J. O. CODDINGTON.

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