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A GUIDE TO THE TYPING OF MATHEMATICAL NOTATION

Dorothy G. Stewart

November 1964

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PREFACE

This Guide has been prepared for secretaries and typists concerned with the preparation of mathematical texts. It is specifically intended for those who must obtain competence from the occasional typing of mathematical notation.

The instructions are based on the techniques used by publishers in the typographical composition of books and journals containing mathematical expressions. The objective is not to limit the mathematician's individual style of notational structure but rather to provide a basis for uniformity so that his publication can be economically and efficiently prepared and will have the best possible appearance.

If the following pages do contain information of value, credit is certainly due to the efforts of Ann Wells, who helped me convert typesetting methods to typewriting methods. Her tact in pointing out faulty instructions was equaled only by her patience in helping me correct them.

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A GUIDE TO THE TYPING OF MATHEMATICAL NOTATION

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1. INTRODUCTION

It is difficult to compile rules for the typing of mathematics because there are almost as many ways of presenting formulae as there are mathematicians. And then there is the problem of terminology--of what to call a particular element that has no particular name. Despite these difficulties, there is a definite need to set forth some basic rules to help technical typists convert a maze of handwritten--and often illegible--symbols into a printed form that will be intelligible and pleasing to the intended audience.

The rules given on the following pages are formulated to help you establish and maintain a consistent style in the typing of mathematics. They are based on the printing practices used by book publishers and mathematical journals. They can--and should be--modified to fit the requirements of the individual author. This is to say, they need not be followed rigidly, but, rather, are intended to help you to know what to do when the author is not around to tell you how to do it.

The instructions, arranged in four major groupings, tell you how to type symbols and fractions, what spacing to use, and how to arrange

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equations--all of which contribute to correct, functional presentatio
Since brevity is essential if instructions are to be useful, cross re
erence has been employed to help you find additional information if
necessary.

In general, you should use double spacing for publications conta
ing mathematical expressions. If large symbols (integrals, summatio
etc.) appear within the text line, the expressions should be displaye
They need not be numbered.

Although Typits have been used in many of the examples, symbols
as integrals, summations, roots, parentheses, brackets, braces, etc.,
can be drawn by hand if Typits, IBM Changeable Type Bars, or other t
of supplementary keys are not available. However, if more than occas
mathematical expressions are to be typed, it is recommended that the
typewriter be equipped for the use of supplementary keys. A fairly
and complete assortment of characters needed for mathematical composi
is obtainable. Once you become adept in the use of such keys, the ta
of typing mathematics will be less arduous and the appearance of the
lication will be enhanced.

2. SYMBOLS

2.1. Roman Letter Symbols

Both capital and lowercase typewritten letters (roman) and script letters are used as symbols in mathematical notation. When typing from handwritten copy, be careful to distinguish between the letter ℓ and the numeral one (1); a capital K and a Greek kappa (K); a lowercase p and a Greek rho (ρ); a lowercase u and a Greek mu (μ); a lowercase v and a Greek nu (ν); a lowercase w and a Greek omega (ω); a capital X and a Greek chi (χ); a lowercase x and a times sign ($\times$). If you do not know which symbol the author intends, do not guess: ask before you type.

2.2. Greek Letter Symbols

If Greek letters are not available on your typewriter, and you do not have access to interchangeable keys or Typits, it is usually preferable to insert Greek letters by hand, unless you are very adept at improvising on the typewriter. For example, a theta can be made by typing a zero and then inserting the bar by overtyping a hyphen through the zero; e.g., θ. Be sure that the bar goes through the <u>center</u> of the zero.

A sigma (σ) can be made by typing a lowercase o and then completing the letter by hand (σ).

A phi (φ) may be written as ϕ or as φ. The first can be made by combining an o and the solidus (/); an interchangeable key or Typit must be used for the second. Do not substitute one for the other; the author may be using both in his notation.

The epsilon may be written as ϵ or as ε. Do not substitute or for the other without checking with the author.

A psi (ψ) can be made by typing a solidus and completing the by hand (e.g., $\not\psi$).

2.3. Functional and Operational Symbols (See also Secs. 2.4.4, 4. and 4.9.2.)

Functional and operational symbols such as those given in the lowing list are typed in lowercase letters without periods. This applies generally to any standard abbreviation of more than one le

sin	sec	tanh	exp	sup	min
cos	csc	coth	log	inf	max
tan	sinh	sech	ln	lub	sgn
cot	cosh	csch	lim	glb	mod

2.4. Superiors and Inferiors (Superscripts and Subscripts) (See a Sec. 4.5.)

Superiors are usually placed directly over inferiors (e.g., D Occasionally, an inferior may precede a superior (e.g., A_i^j); or i precede the symbol to which it is attached ($_2F_2$). Check such usag the author before typing.

To type an inferior or superior, roll the platen one-half spa below or above the main line.

$$v_{r-1,r}^{-1}; \quad x_1; \quad n^{(r)}; \quad e^{-(x-A)/\theta}$$

Do not space between a symbol and a superior or inferior. If typewriter is not equipped with half-spacing, make certain that th

inferiors and superiors are typed sufficiently below or above the line to be readily distinguished as inferiors and superiors. Carelessness may result in ambiguity.

2.4.1. Superiors and Inferiors Used with Parentheses or Brackets. Superiors and inferiors should be typed close to a parenthesis or bracket.

$$2\left[\frac{32a^2}{(1-a^2)^2}\left(\frac{1-a}{1+a}\right)^{\pi+(2/a)}\right]^2$$

When parentheses and brackets must be inserted by hand, allow one space between the symbol preceding the parenthesis or bracket and the superior or inferior.

$$k_r(n) = [n_r - 1, \ldots, n_2 - 1, n_1]_{r-1}; \quad \left[\frac{df(x)}{dx}\right]_{x=a}$$

2.4.2. Superiors and Inferiors Used with Integrals, Summations, Products, and Intersections. (See also Sec. 2.6.) In displayed equations, superiors and inferiors used with summations, products, and intersections should be typed one full space above and below these symbols.

$$\sum_{n=1}^{n}; \quad \prod_{j=1}^{t=1} \quad \bigcap_{u=s}^{p-1}$$

In text, superiors and inferiors are typed to the right of summations, products, and intersections. Do not space between the symbol and its superior or inferior. To type a superior to a summation, product, or intersection, roll the platen one-half space up;

to type an inferior, roll the platen one-half space down from the main li

$$\Sigma_{n=1}^{n}; \quad \Pi_{p=1}^{t=1}; \quad \cap_{u=s}^{p-1}$$

Superiors and inferiors are usually typed to the right of the integr both in displayed equations and in the text. Do not space between the symbol and its superior or inferior. To type a superior to the small int gral, roll the platen one-half space up. To type a superior to a large integral, roll the platen up one and one-half spaces. To type an inferi to either the small or large integral, roll the platen one full space dow from the main line. (To type an inferior to a superior or a second infe to an inferior, roll the platen down an additional half space.)

$$\int_{0}^{t_1-u_1}; \quad \int_{H_0}; \quad \int_{-R}^{R} \text{(text)}$$

Occasionally (when the expression signifies a region of integration the inferior is centered under the integral or under multiple integrals (roll the platen down one full space below the integral). If you are no sure of the author's intent, ask before you type.

$$\int_{(a)}; \quad \iint_{R_1}; \quad \iiint_{V}$$

Complex inferiors to summations and products are sometimes typed in two lines; or they can be typed in one line, centered under the symbol, and separated by a semicolon.

$$\sum_{\substack{i=1 \\ j-0}}; \quad \prod_{\substack{a=1 \\ a=j}}; \quad \sum_{uvw;ijh}$$

2.4.3. Superiors and Inferiors Used with a Single Vertical Bar. Superiors and inferiors should be typed to the right of a single vertical bar denoting a sign of substitution. If the vertical bar is to be inserted by hand, allow one space between the symbol preceding the bar and the superior or inferior.

$$\left.\frac{\partial P_\theta(S_i)}{\partial\theta}\right|_{\theta=0}; \qquad f(x)\Big|_1^2$$

2.4.4. Inferiors to Operational Symbols. In display, inferiors to operational symbols should be typed one full space below the main line.

min;	max;	sup;	inf;	lim;	glb;	lub;	lim sup;	lim inf
$\emptyset$	F	a	b	$n\to\infty$	f	p	$n\to\infty$	$n\to\infty$

In text, inferiors to operational symbols are placed to the right of the symbol, one-half space below the main line (e.g., $\lim_{n\to\infty}$; $\max_G$).

2.4.5. Abbreviations as Inferiors. When words and abbreviations of words are used as inferiors, they are typed with lower-case letters.

$$V = \mathrm{Vol}_{\mathrm{shear}}; \qquad W_{w_{\mathrm{opt}}} = w(\mathrm{Vol})_{\mathrm{opt}}; \qquad V = \mathrm{Rv}_{\mathrm{max}}$$

2.4.6. Primes and Asterisks. Primes and asterisks are usually placed directly over inferiors (e.g., x_1'; A_1^*). Occasionally, an asterisk or prime may precede an inferior (e.g., $A^*_j - a_1$), or it may precede the symbol to which it is attached (e.g., $'f^2$; $^*A^{\alpha\beta}$). (If you are not sure of the author's intent, ask before you type.)

Typit keys should be used to type the single prime (K'), double prime (K''), and triple prime (K''') (the apostrophe can be used if Typits are not available). Do not confuse the prime with the numeral "one," which is sold

used as a superior (however, minus one (-1) is used as a superior). If the prime belongs to an inferior, it should be placed next to it (e.g., $r_{d'}$).

2.4.7. Superiors and Inferiors in Fractions. (See also Sec. 3.1.4.) If a superior occurs in the denominator of a fraction, roll the platen one and one-half spaces below the fraction bar and type the symbol to which the superior is to be attached; roll the platen up one-half space and type the superior. The superior must not touch the fraction bar.

$$\frac{(s+1)^{n+1}}{s^{n+2}}$$

If an inferior occurs in the numerator of a fraction, roll the platen one-half space above the fraction bar and type the symbol to which the inferior is to be attached; roll the platen down and type the inferior. The inferior must not touch the fraction bar.

$$\frac{2b_1 - 1}{k}$$

2.4.8. Punctuation with Superiors and Inferiors. Superiors and inferiors precede all punctuation except the period of an abbreviation.

$$x = 2y^2, \quad \text{in.}^2$$

2.5. Second Superiors and Inferiors

To type a superior to a superior, roll the platen one-half space above the main line and type the first superior; roll it up an additional half space for the second superior. To type an inferior to a superior, roll the platen one full space above the main line and type the superior;

roll it down one-half space and type the inferior.

$e^{-\frac{1}{2}y^2}$ (superior to superior); $e^{s_r t}$ (inferior to superior)

To type an inferior to an inferior, roll the platen one-half space down from the main line and type the first inferior; roll it down an additional half space for the second inferior. To type a superior to an inferior, roll the platen down one full space below the main line and type the inferior; roll it up one-half space for the superior.

$p^2_{ik_u}$ (inferior to inferior); $g_{N^2}(s)$ (superior to inferior)

2.6. Integrals, Summations, and Products (See also Secs. 2.4.2 and 4.7.)

2.6.1. Integrals, Summations, and Products in Display. In displayed equations, use the large integral, large summation, and large product. Superiors and inferiors should be placed to the right of the integral (see Sec. 2.4.2). Superiors and inferiors should be typed above and below summations and products (see Sec. 2.4.2).

$$\int_0^1 ; \quad \sum_{i=1}^{p-s-1} ; \quad \prod_{u=0}^{p-1}$$

2.6.2. Integrals, Summations, and Products in Text. In the text, use the small integral, the capital sigma, and the capital Greek pi.

$$\int_0^1 ; \quad \Sigma_{i=1}^{p-s-1} ; \quad \Pi_{u=0}^{p-1}$$

Superiors and inferiors used with these symbols in the text should be placed to the right of the symbol (see Sec. 2.4.2). Do not space betwe the symbol and its superior or inferior.

2.6.3. Integrals, Summations, and Products in Fractions. If an integral, summation, or product occurs in the numerator or denominator a fraction, use the small integral, the capital sigma, and the capital

$$E = \frac{\int_0^1 f(x)\,dx}{F(x - y)} \; ; \quad y_j^* = \frac{\sum_{i=1}^{n} A_{ji}}{\sum_{j=1}^{} \sum_{i=1}^{} A_{ji}} \; ; \quad K = \frac{M^{a/2}}{\prod_{a} M(a - y)} \; ; \quad a = \frac{a_0}{1 - \int_0^{t_0}}$$

Note that superiors and inferiors to integrals are placed to the right the integral; those to summations and products are usually typed above below these symbols.

If an integral, summation, or product occurring in the numerator fraction has an inferior, roll the platen up one full space and type th symbol; then roll it one full space down and type the inferior (the inf must not touch the fraction bar). If an integral does not have an infe roll the platen up one-half space and type the symbol. If a summation product does not have an inferior, type the symbol on the line.

If a summation or product occurring in the denominator of a fracti has a superior, roll the platen down two full spaces and type the symb then roll the platen up one full space and type the superior (the super must not touch the fraction bar). If a summation or product does not h a superior, roll the platen down one full space and type the symbol. T type an integral (with or without a superior) in the denominator of a fraction, roll the platen down one and one-half spaces.

2.6.4. Integrals and Summations in Matrices and Determinants. (See also Sec. 4.7.) If integrals or summations occur in matrices or determinants, use the small symbols.

$$f(s) = \left|\int_0^\infty e^{-st}\varphi_{ij}\,dt - \delta_{ij}\right| = \begin{vmatrix} \int_0^\infty e^{-st}\varphi_{11}\,dt - 1 & \int_0^\infty e^{-st}\varphi_{12}\,dt \\ \int_0^\infty e^{-st}\varphi_{21}\,dt & \int_0^\infty e^{-st}\varphi_{22}\,dt - 1 \end{vmatrix} = 0$$

$$\operatorname{cov}(Y_n - Y_0, X_n) = \begin{pmatrix} \Sigma_{11n} & \Sigma_{12n} \\ \Sigma_{21n} & \Sigma_{22n} \end{pmatrix}$$

$$\sum = \begin{bmatrix} \Sigma_{11} & \cdots & \Sigma_{1p} \\ \vdots & & \vdots \\ \Sigma_{1p} & \cdots & \Sigma_{pp} \end{bmatrix}$$

Note that in a matrix or determinant, superiors and inferiors are placed to the right of both integrals and summations.

2.6.5. Integrals Used with Absolute-value Signs. (See also Secs. 2.9 and 4.9.2.) If an integral in a displayed equation occurs within absolute-value signs, use the large integral.

$$\left|\int_a^b G(x)\,dF(x)\right| \leq \int_a^b |G(x)|\,dF(x)$$

2.7. Parentheses, Brackets, and Braces (See also Sec. 4.11.)

These grouping symbols are usually used in the following sequence:

$$(\{[\,[\,[\,(\,)\,]\,]\,]\})$$

Note that the large symbols should only be used to extend the sequence when necessary. Do not alter the grouping symbols enclosing single elements or groups of elements without checking with the author; certain elements are enclosed within specific grouping symbols.

$$\{x_j\};\ \{f_j(x)\};\ [0,\ 1];\ (0,\ 1);\ (0,\ 1];\ [0,\ 1);\ f(x(t))$$

Grouping symbols should be the same height as the largest expression contained within them. It is not necessary to increase the size of the grouping symbols to enclose superiors or inferiors. If a grouping symbol must be hand-drawn, allow one space for its insertion.

$$\{[a_1z_1 + \cdots + a_mz_m] - [a_1r_1(t) + \cdots + a_mr_m(t)]\}$$

$$\rho\sigma_1\sigma_2 = \sum_{n=1}^{\infty} \int_0^{\infty} nt\, d_t\left[\int_0^t A(t;y)\, dB^{(n)}(y)\right] - \nu_1\mu_1$$

$$u'' - \left(1 + \sum_{k=1}^{R} s_1 e^{-\lambda_k t}\right) u = 0$$

2.7.1. Parentheses and Brackets Used with Fractions. When the expression enclosed includes a built-up fraction of two levels, large parentheses can be used. For a fraction of more than two levels, brackets may be substituted for parentheses. (In such cases, the brackets will have to be hand-drawn; allow one space for the insertion of each bracket.)

$$\left(s_2 - \frac{n+1}{2}\right);\quad \left[\frac{1 + \frac{2b}{a}\frac{\lambda}{2a}}{1 + \frac{\lambda}{2a}}\right]$$

2.7.2. Parentheses and Brackets Used with Radicals. See also Secs. 2.8 and 4.8.) When parentheses or brackets contain a radical, they should be large enough to enclose the radical.

$$\left(x - \sqrt{\frac{E}{N_0}}\right)^2; \quad t_1 = \frac{I}{T}\left[\sqrt{\left(x_2^1\right) + \frac{2Tq}{I}} - x_2^1\right]$$

2.7.3. Angle Brackets. When angle brackets are needed, Typits should be used or the bracket should be hand-drawn (allow one space for insertion of each bracket). Do not substitute the "is greater than" or "is less than" sign. Large angle brackets can be typed by using the Typit keys labeled "variations" and "of the."

$$\langle (sL)^2 \rangle = \int_0^h \int_0^h \langle \delta n(z_1)\ \delta n(z_2) \rangle\ d_{31}\ d_{32}$$

$$\rho(l) = \left\langle \left(\frac{\delta I}{I_0}\right)_1 \left(\frac{\delta I}{I_0}\right)_2 \right\rangle$$

2.8. Radicals (Roots) (See also Sec. 4.8.)

A radical sign should always be large enough to contain the entire quantity to which the sign pertains. The horizontal bar (vinculum) should extend over the complete expression; ambiguity can result when the termination of a radical is not clear (e.g., $\sqrt{a + bx}$, not $\sqrt{a + b}x$). The horizontal bar for the single-line radical can be made by rolling the platen up one full space and typing one or more underlines; the bar for the double-line radical can be made by rolling the platen up two full spaces and typing one or more underlines.

The small radical sign should be used if the symbol within it does not have a superior (a single inferior may extend beyond the radical sig

$$a = \sqrt{E} + n_1^*; \quad \sqrt{E}_0 = -\sqrt{E}_1$$

If any symbol within the radical has a superior, the large radical sign should be used. Roll the platen down one-half space and type the radica then roll it up one-half space and type the first symbol.

$$\sqrt{x_1^2 + y_1^2} < \sqrt{x_i^2 + y_i^2}$$

If the radical contains a fraction, use the large radical sign. Roll the platen down one-half space and type the radical; roll it up one full space and type the numerator and then the fraction bar (use the underscc roll the platen down one full space and type the denominator. Note th the expression preceding the radical aligns with the fraction bar.

$$x = \sqrt{\left[\frac{2D}{2x}(t)\right]^2}$$

If the expression within a radical is complex, ask the author to simplify it to eliminate the radical sign. For example,

$$\sqrt{1 + \left[\frac{\frac{2D}{2v}(t_{n-1})}{\frac{2D}{2v}(t_n)}\right]^2}$$

can be simplified to

$$\left(1 + \left[\frac{\frac{2D}{v}(t_{n-1})}{\frac{2D}{2v}(t_n)}\right]^2\right)^{\frac{1}{2}}$$

2.8.1. Radicals within the Text. In text, both the small and the large radical signs can be used. However, if possible, it is better to display expressions involving the use of the large radical. To insert the large radical, roll the platen down one-half space and type the radical; then roll the platen up to the text line and type the first symbol. (Note that the text line aligns with the symbols within the radical.)

... for which $\sqrt{x^2 + y^2}\ \sqrt{E_i}/N_0 > 1$

If the radical contains a fraction, ask the author to "turn" the fraction so that it can be typed in a single line. For example,

... values of m and $\sqrt{\frac{E}{N_0}}$

should be typed

... values of m and $\sqrt{E/N_0}$

2.8.2. Radicals in the Numerator and/or Denominator of Fractions. (See also Sec. 4.8.) In the numerator and/or denominator of a fraction, either the small or large radical sign can be used as needed.

$$\frac{\sqrt{x^2 + y^2}\sqrt{E_i}}{N_0}\ ;\quad \frac{\sqrt{E_{i-1}} + \sqrt{E_i}}{2\sqrt{N_0}}$$

If the radical in either the numerator or denominator of a fraction contains a fraction, ask the author to "turn" the fraction so that it can be typed in a single line. For example,

$$\frac{\left(x - \sqrt{\frac{E}{N_0}}\right)^2}{2}$$

should be typed

$$\frac{(x - \sqrt{E/N_0})^2}{2}$$

2.9. Absolute-value Signs (See also Secs. 2.4.3, 2.6.5, 4.1, and 4.

The height of an absolute-value sign is determined by the height of the quantity to which it pertains.

$$|x - x_0| < \delta; \qquad \left|\sum_{n=1}^{\infty} u_n\right| \leq \sum_{n=1}^{\infty} |u_n|$$

$$v_n^c = \frac{|D_{n-1}|}{\left|\frac{\partial D}{\partial v}(t_n)\right|}; \qquad \left|I - \int_0^{\infty} e^{-st} B(t)\, dt\right| = 0; \qquad \int^{\infty} \left|\frac{g'(t)}{g(t)}\right| dt < \infty$$

2.10. Exponentials (See also Sec. 4.10.)

An exponential can be expressed either by the symbol "e" or by "exp," depending on the complexity of the superscript. In a displaye equation, the expression

$$e^{-\frac{c^2}{1+r}}$$

should be typed as

$$e^{-[c^2/(1+r)]} \quad \text{or} \quad \exp\left(-\frac{c^2}{1+r}\right)$$

Note that to simplify a superscript, parentheses, brackets, and sometimes braces must be used to enclose certain elements. Ask the author to simplify these expressions before you type them.

The "exp" form should always be used if the superscript is elaborate or if it contains an integral or summation. For example,

$$e^{-\int_0^t u(s)\,ds} \qquad \text{and} \qquad e^{-\sum_{i=1}^{n} I(X_i>A_n-\epsilon)}$$

should be typed as

$$\exp\left[-\int_0^t u(s)\,ds\right] \quad \text{and} \quad \exp\left[-\sum_{i=1}^{n} I(X_i > A_n - \epsilon)\right]$$

Both the "e" and "exp" forms may be used in the same equation. For example,

$$x(t) = \exp\left[\int_0^t u(s)\,ds\right]e^{\lambda t}y(t)$$

2.11. Binomial Expressions

To type a binomial in either the text line or a displayed equation, roll the platen up one-half space and type the top integer; then roll the platen down one full space and type the bottom integer.

... the general binomial $\binom{k}{r}$ ... (in text line)

$$\Pr(A_i) = \binom{r}{i} p_j^i (1 - p_j)^{r-1} \quad \text{(in displayed equation)}$$

If the top integer has an inferior, roll the platen up one full space and type the main symbol and then roll it down one-half space and type the inferior; roll the platen down an additional full space and type the bottom integer.

$$n = \binom{n_r}{r} + \binom{n_{r-1}}{r-1} + \cdots + \binom{n_i}{i}$$

2.12. Embellished Symbols and Overscores

When a dot, bar, tilde, circumflex, or arrow is used over a symbo ($\dot{x}$, $\ddot{x}$, $\bar{x}$, $\tilde{x}$, $\hat{x}$, $\vec{x}$), it should be placed as close to the symbol as pos without actually touching it. If a bar occurs under a symbol, check w the author. Symbols should never be underscored for emphasis (italics even when they occur in an italicized text line.

... the integral M(t) is defined for t in ...

When overscores are used to indicate mathematical operations or groupings, make certain that the extent of each overscore is clearly shown.

$$\phi_{zz} = \overline{(z - \bar{z})(z - \bar{z}_t)_t} = \overline{(z_r)(z_r)_t}$$

If superiors are attached to the overscore, ask the author to simplify the expression. For example,

$$R_\theta^* = C_0 \min_{\gamma_\sigma} \overline{|\theta - \gamma_\sigma|^2}^{S,N} = C_0 \overline{|\theta - \gamma_\sigma^*(\theta|V)|^2}^{V}$$

can be written as

$$R_\theta^* = C_0 \min_{\gamma_\sigma} (|\theta - \gamma_\sigma|^2)^{S,N} = C_0 (|\theta - \gamma_\sigma^*(\theta|V)|^2)^{V}$$

3. FRACTIONS

3.1. Numerical Fractions (See also Sec. 4.18.)

Numerical fractions can be typed in three different ways: using the solidus (slant bar); using Typits to create "small" fractions; using the numerals on the typewriter to create large, built-up fractions:

1/2 (solidus fraction); ½ (Typit "small" fraction);

$\frac{1}{2}$ (large built-up numerical fraction)

(Note that "small" fractions can be created from Typits by using superiors and inferiors; e.g., the fraction $^{1}/_{12}$ very closely matches the single-piece Typit fraction ¹/₁₂.)

3.1.1. Numerical Fractions in Text. If you have access to Typit fractions, they should be used in the text line; otherwise use the solidus fraction. Do not use built-up fractions in the text line.

... w_r is identically ½ for $s = 0$; or

... w_r is identically 1/2 for $s = 0$

3.1.2. Numerical Fractions in Displayed Equations. If there is no built-up literal fraction (one in which either numerator or denominator, or both, is a letter) or large symbol in the equation, use a Typit small fraction if available; otherwise use a large built-up numerical fraction. Do not use a solidus fraction in displayed equations.

$V = \frac{1}{2}k_i A_r B$ (preferred); $V = \frac{1}{2} k_i A_r B$ (acceptable)

superiors. To type either fraction, roll the platen up one-half space.

$$\frac{u}{u_0} = (t)^{\frac{3}{2}}\left(\frac{s+1}{s+t}\right) \quad \text{or} \quad \frac{u}{u_0} = (t)^{3/2}\left(\frac{s+1}{s+t}\right)$$

If a superior numerical fraction occurs in the denominator of a fraction, roll the platen down one and one-half spaces and type the symbol to which the superior is attached; then roll the platen up one-half space and type the superior.

$$\frac{u_e}{(2\xi)^{\frac{1}{2}}} \quad \text{or} \quad \frac{u_e}{(2\xi)^{1/2}}$$

3.2. Literal Fractions (See also Sec. 3.1.3.)

A literal fraction is one in which either the numerator or the denominator, or both, is a letter (Roman, Greek, German, etc.). Literal fractions can be typed in two ways: as solidus (/) fractions or as built-up fractions.

$(u_e/u_\infty)^2 = 0$ (in text line); $\left(\frac{u_e}{u_\infty}\right)^2 = 0$ (in displayed equation)

3.2.1. Literal Fractions in Text. Do not use built-up literal fractions in the text line. Ask the author to "turn" the fraction so that it can be typed with a solidus. For example, in the text line

$$f''_w = \frac{\rho_w v_w}{\rho_e u_e}\sqrt{(Re_x)} \text{ for which } f''_w \sim \left(\frac{du}{dy}\right)_w = 0$$

should be typed as

$$f''_w = (\rho_w v_w)/(\rho_e u_e)\sqrt{(Re_x)} \text{ for which } f''_w \sim (du/dy)_w = 0$$

3.2.2. Literal Fractions in Displayed Equations. In displayed equations, literal fractions are usually built up.

$$f = \frac{k_2 V}{2} \; ; \qquad V = \frac{\frac{1}{\gamma + 1} - \frac{m}{2(m+2)}}{\lambda^{m+2}} + \frac{m}{2(m+2)}$$

3.2.3. Literal Fractions in the Numerator and/or Denominator of a Fraction. Built-up literal fractions are usually used in both numerator and denominator of a fraction.

$$\frac{\frac{1}{u_\delta}\frac{du_\delta}{dx}}{\frac{1}{p_\delta N}\frac{d}{dx}(p_\delta N)} \; ; \qquad \frac{\frac{1}{N}\frac{dN}{dx}}{\frac{1}{p_\delta}\frac{dp_\delta}{dx}} = m = \text{const}; \qquad \frac{u_\delta^2}{H_\delta} = \frac{2}{1 + \frac{2}{\gamma - 1}\frac{1}{M_\delta^2}}$$

However, if both the numerator and denominator consist of a single built-up fraction, the solidus should be used in both numerator and denominator. For example,

$$\frac{dR}{d\theta} = \frac{\frac{dR}{dt}}{\frac{d\theta}{dt}} = R_0 \tan \gamma_0$$

should be typed

$$\frac{dR}{d\theta} = \frac{dR/dt}{d\theta/dt} = R_0 \tan \gamma_0$$

Also, when either the numerator or denominator is complex, making the

fraction difficult to read, the solidus should be used. For example,

$$\frac{K'^2 - G}{1 + \dfrac{\frac{1}{N}\frac{dN}{dx}}{\frac{1}{p}\frac{dp_\delta}{dx}}}$$

would be more readable typed as follows:

$$\frac{K'^2 - G}{1 + \left(\frac{1}{N}\frac{dN}{dx}\right)\Big/\left(\frac{1}{p}\frac{dp_\delta}{dx}\right)}$$

Note that the solidus can be made by using the Typit sign labeled "variations."

3.2.4. Literal Fractions as Superiors. Use the solidus for literal fractions as superiors. Do not use built-up literal fractions as superiors. For example,

$$y' + \beta_1 \lambda^{\frac{2\gamma-5-j}{2(\gamma-1)}} y^{\frac{3+j}{2(1+j)}} = \beta_2 \lambda^{\frac{j+\gamma}{\gamma-1}}$$

should be typed

$$y' + \beta_1 \lambda^{(2\gamma-5-j)/2(\gamma-1)} y^{(3+j)/2(1+j)} = \beta_2 \lambda^{(j+\gamma)/(\gamma-1)}$$

4. SPACING

4.1. Roman Letter Symbols and Greek Letter Symbols

Do not insert space between symbols that multiply or between a number and the symbol it multiplies (for exceptions, see Sec. 4.12).

$$c_i p_i(\theta); \qquad Y' = 2AX + NA^2; \qquad T_{0B}^2 = aSr^2 + 2bSrd + cSd^2$$

Do not insert space between a number or a symbol preceding or following a vertical bar (for exception, see Sec. 4.9).

$$p_t(n|n); \qquad E(x - 1|x \geq 1); \qquad |x| \to \infty$$

Insert one space between adjacent symbols or numbers separated by commas.

$$\phi = A(X, h, V, \gamma, m, L, \alpha, \epsilon) = 0; \qquad B = 1, 2, \ldots, h$$

Do not insert space between a symbol or number and a parenthesis, bracket, or brace.

$$10(r - 1)\theta; \qquad g_0[r/r(r + s)]^2; \qquad E\{[n(t) - v][n(t + r) - v]'\}$$

4.2. Signs of Operation

Insert one space before and after a sign of operation (+, ±, ∓, ×, ·, ÷) (for exceptions, see Sec. 4.5).

$$7p^2 - 4 + (13p - 2)n^2 + 4n^4; \qquad A_k^{2m+1}(p) \cdot \epsilon_k$$

$$r \pm t_c s'_\tau \left(\frac{1}{N} + \frac{1}{ghN}\right)^{\frac{1}{2}}; \qquad y = c \mp \mu_\tau\left(\frac{\pi}{2}\right)$$

Do not insert a space following a sign that belongs only to the symbol letter symbol; number; functional or operational symbol (see Sec. 2.3 and Sec. 4.6); summation or integral (note the illusion of space between the minus sign and the summation because of the inferior to the summation).

$$a(-\infty, x_0) = 0; \qquad -b + \lambda + a; \qquad d_1 = -32 + N; \qquad J = 0, \pm 1, \pm 2$$

$$R_1(s) \leq -c_1 < 0; \qquad \sin(-x) = -\sin x; \qquad k_2 = \frac{-\log 0.1}{\log x}$$

$$p_1(s) = -\sum_{i=0}^{m} B_{ig}(\omega_m - \omega_i)e^{-w_m s}; \qquad -\int_0^{\infty} Z\, ds = -\int_0^{\infty} e^{At} Ce^{Bt}\, dt$$

Allow one space after a sign preceding a radical or fraction.

$$\sqrt{E}_0 = -\sqrt{E}_1; \qquad \frac{\partial z}{\partial y} = z_y - \frac{\phi_y}{\phi_z}; \qquad y'' = -\tfrac{1}{2}y'^2$$

4.3. Equality and Inequality Signs, Etc.

Allow one space before and after the following signs: $=$, $\neq$, $\equiv$, $\rightarrow$, $<$, $>$, $\propto$, $\leq$, $\geq$, $\sim$, $\cong$ (for exceptions, see Sec. 4.5).

$$v_n = 0; \qquad x_i \neq 0; \qquad \gamma_0(V) \equiv \gamma_0(S/V); \qquad x \rightarrow \infty; \qquad a_k < b_k;$$

$$X > 0; \qquad y \propto x; \qquad 0 \leq \lambda \leq 1; \qquad y \geq 0; \qquad Q \sim Q_s; \qquad \omega_M \cong E$$

4.4. Logic Symbols

Allow one space before and after the following symbols: $\subset$, $\supset$, $\cup$, $\cap$, $\in$, $\notin$.

$$C \subset B; \qquad U \supset B; \qquad R_i \cup R_{i+1}; \qquad S_{i+1} \cap T_i; \qquad x \in R; \qquad P_j \notin L_r \cup L_{r+1}$$

Note that "ϵ" or "$\mathcal{E}$" is sometimes used in place of the sign "$\in$."

$$c \epsilon C_i; \qquad j \mathcal{E} Z$$

4.5. Superiors and Inferiors

Do not space before or after signs of operation, signs of equality or inequality, logic symbols, etc., in superiors or inferiors.

$$e^{(t+\theta)x-b(\theta)}; \qquad X_{t+n-v,n}; \qquad \int_{L_i \cap E};$$

$$\sum_{i \in S(n+1)}; \qquad \lim_{n \to \infty}; \qquad \max_{j-k \leq n\delta}$$

4.6. Functional and Operational Symbols (See also Secs. 2.3 and 2.4.4.)

Insert one space before and after a functional or operational symbol insert one space following the element (argument) belonging to the symbo

$$\sin (x \pm y) = \sin x \cos y \pm \cos x \sin y$$

$$\tan (x \pm y) = \frac{\tan x \pm \tan y}{1 \pm \tan x \tan y}; \qquad \lim_{t} x(t) = y$$

$$f_k(s) = \min_{x} Q(x, s); \qquad \log y = \log c + x \log k$$

$$F(s, t) = \exp [s^{Z(t)}]$$

Insert one space between grouped functional or operational symbols.

$$\log \log \log x; \qquad \log \cos \phi$$

Note that when one or more functional symbols have complex inferiors,

one space is used between the inferiors rather than between the functional symbols.

$$\min_{(x_1,x_2,\ldots,x_n)} \max_{(y_1,y_2,\ldots,y_n)} = \min_{x_1} \max_{y_1} \min_{(x_2,\ldots,x_n)} \max_{(y_2,\ldots,y_n)}$$

4.7. Integrals, Summations, and Products (See also Sec. 2.6.)

Insert one space before and after an integral, summation, or product (unless an operation sign that applies only to the integral or summation precedes the symbol; see Sec. 4.2).

$$g(c) = r \int_0^\infty g(ce^x - 1) \exp[-b(ce^x - 1)]e^x \, dx; \qquad P = \int D \, dV$$

$$s'x - s'x^* = -\mu \sum_{(g,h)\in 0} \nu_{gh}^0 s_{gh}; \qquad \sigma = \sum n_r s_r; \qquad \sum x_i^4 = 3 \sum x_i^2 x_j^2$$

$$E[y(x_1, x_2, \cdots, x_m)] = \prod_{i=1}^{n} [I + c(x_i)A_i]$$

4.7.1. Multiple Integrals. Multiple integrals without superiors or inferiors, or with a common inferior, should be typed without space between the symbols but with one space before and after the group of symbols.

$$M = \iiint \rho \, dV; \qquad u(P) = \frac{1}{A} \iint_S u \, dS$$

When multiple integrals have superiors, allow one space between the

symbols as well as before and after the group of symbols.

$$d_N = \int_0^T g_N^2(s)\ ds - \int_0^T \int_0^T K_{N-1}(s,\ t) g_N(t)\ ds\ dt$$

4.7.2. Multiple Summations. Allow one space between adjacent multiple summations and one space before and after the group of symbo

$$T^2 = \sum \sum b_{ij} x_i x_j; \qquad \mathrm{Var} \sum_{i<j} \sum a_{ij}\ f(r_{ij}) = \sum_{i<j} \sum a_{ij}^2\ \mathrm{Var}\ f(r_{ij})$$

When one or more adjacent summations have complex inferiors, one space is used before and after the inferiors rather than between the summations.

$$y = \sum_{i=1}\ \sum_{k=n_{i-1}+1}\ x_k b^k$$

4.7.3. Adjacent Integrals and Summations. Allow one space betw adjacent integrals and summations.

$$I(s) = \sum_{n=0} \int^{+\infty} fn(x)\ dx$$

4.8. Radicals

Allow one space between the radical sign and a letter or numeral preceding or following it.

$$T_{min} = 4 \sqrt{3}\ \frac{N}{3}\ T; \qquad \psi = \omega \sqrt{kc}\ [illegible] \qquad V = \tan^2 \frac{t \sqrt{\mu}}{2}$$

Allow one space between adjacent radical signs.

$$\sqrt{-2}\,\sqrt{-3} = (\sqrt{-1})^2\,\sqrt{2}\,\sqrt{3} = \sqrt{6}$$

Allow one space between a built-up fraction and a radical sign.

$$\psi = \frac{t}{2}\sqrt{-\mu}$$

Allow one space between a small fraction and a radical sign.

$$\tfrac{1}{2}\sqrt{r_k a_k} = V_k$$

Allow one space between a radical sign and a parenthesis or bracket.

$$\sqrt{2}\,(1 - \mu_0^2)F_k(0); \qquad \sqrt{2}\,[J_k(\tau) - K_k(\tau)]$$

4.9. Vertical Bars (Absolute-value Signs, Norm Signs, Etc.) (See also Sec. 4.1.)

Do not insert space between adjacent single vertical bars or between adjacent double and single vertical bars.

$$\left|\sum\right| = |\Delta||P|; \qquad \lim_{k\to\infty}\int_{C_k} \|e^{ta}R^{-1}(s)\|\,ds\| = 0$$

Note that one space must be inserted before and after a summation enclosed by vertical bars.

Insert one space between adjacent double vertical bars.

$$\|x(t + h_m)\| \le c + c_1 \sum_{n=0}^{m} \int_{t_0}^{t} \|D_n(s)\|\,\|x(s + h_n)\|\,ds$$

Do not insert space between a preceding superior and a vertical bar.

$$\sum e^{itrAx} = |\Lambda|^{n/2}|\Lambda - 2iA|^{-n/2}$$

Do not insert space between a vertical bar and a bracket or parenthesis.

$$|s| = |y|[1 + 0(1)]; \qquad f(u, v) = 0(|u| + |v|)$$

4.9.1. Vertical Bars Adjacent to Summations and Integrals. Do not insert space between a summation or integral sign and a vertical bar.

$$\sum_{i=1} |a_i t_1 + b_i t_2| = 1; \qquad \int_\Omega |fg| \, d\Omega \leq \|f\| \cdot \|g\|$$

4.9.2. Vertical Bars Adjacent to Functional or Operational Symb

Insert one space between a functional or operational symbol and a vert bar.

$$\lim_{t \to \infty} \|y(t)\| = 0; \qquad x + m \log |x + iy| = c$$

4.10. Exponentials (See also Sec. 2.10.)

When an exponential is expressed by the symbol "e," do not insert space between this symbol and a letter symbol (Roman or Greek), a parenthesis, or a bracket (except preceding a differential or derivative; s Sec. 4.12).

$$u(t) \sim e^{s_0 t} c; \qquad \int_0^\infty s\phi e^{-st} \, dt; \qquad u(t) = e^{s(t)}[1 + 0(t^{-1})]$$

If the exponential is expressed by "exp," insert one space before and after "exp."

$$c_4 > 2c_5 \exp\left[2c \int_{\omega}^{\infty} \phi(s)\ ds\right]$$

4.11. Parentheses, Brackets, and Braces (See also Sec. 2.7.)

Do not insert space between a letter symbol (Roman or Greek) and an opening or closing parenthesis, bracket, or brace (except preceding a differential or derivative; see Sec. 4.12).

$$p(t) = -\int_{t_0}^{t} a(t_1)u(t_1)k_1(t - t_1)\ dt_1$$

$$f'(x) - \lambda\{\tfrac{1}{2}[f(x - h) + f(x + h)]\} = g(x)$$

Do not insert space between adjacent parentheses, brackets, or braces.

$$[(n - m) + 1](m + 1) = (n - 2m)(m + 1) + (m + 1)^2$$

4.12. Differentials and Derivatives

Insert one space before pairs of symbols beginning with "d," "Δ," or "∂," except in the denominator of a fraction.

$$P\,dx + Q\,dy + R\,dz = 0; \quad \Delta y = f'(x)\,\Delta x + \epsilon\,\Delta x; \quad 2b = \frac{\partial^2 f}{\partial e_1 \partial e_2}$$

$$L = \int_0^h n\,dz; \quad \Phi = L\,du^2 + 2M\,du\,dv + N\,dv^2; \quad a_n = \int_{-1}^{1} t^n\,dg(t)$$

4.13. Matrices and Determinants

Single-space between the rows in a matrix or determinant; allc four spaces between the columns (measured from the longest element each column). The groups of three horizontally placed dots align a are typed without additional space between them; they are precede followed by four spaces (measured from the longest element in the ceding and following columns). Allow one-half space between the v cally placed dots and one and one-half spaces before and after eac group of three; that is, roll the platen down one and one-half spac from the line above (measured from the subscript) and type the fi dot; roll the platen down an additional half space for the second third dot; roll the platen down one and one-half spaces and type t last line.

$$f(x) = [A - xI] = \begin{bmatrix} a_{11} - x & a_{12} & \cdots & a_{1N} \\ a_{21} & a_{22} - x & \cdots & a_{2N} \\ \vdots & \vdots & & \vdots \\ a_{N1} & a_{N2} & \cdots & a_{NN} - x \end{bmatrix} = 0$$

A single element can either center on a multiple element (see examp above) or align with it (see example below).

$$f(x) = [A - xI] = \begin{bmatrix} a_{11} - x & a_{12} & \cdots & a_{1N} \\ a_{21} & a_{22} - x & \cdots & a_{2N} \\ \vdots & \vdots & & \vdots \\ a_{N1} & a_{N2} & \cdots & a_{NN} - x \end{bmatrix} = 0$$

4.14. Factorial Sign

Do not insert space between a factorial sign and the element that precedes or follows it.

... n lies between a! and b!. (in text line)

$$\sum_{\beta=0}^{(n/2)} \frac{1}{2^{\beta}\beta!(n-2\beta)!} > \sqrt{\frac{1}{n!}}$$ (in displayed equation)

4.15. Abbreviations of Mathematical Terms (See also Sec. 4.6.)

Insert one space before and after abbreviations such as det, tr, re, cov, etc.

$$K(s, t) = \operatorname{cov}[x(s), x(t)]; \quad \|h\|_K^2 = \operatorname{var}[(h, x)_K]$$

$$\max_{\|c\|=1} \operatorname{var} c'\hat{a} = \max_{\|c\|=1} c'M^{-1}c; \quad \sum_{i=1}^{M} \operatorname{tr}(x_i) = 1$$

$$\operatorname{tr}(AB) = \operatorname{tr}(BA); \quad -c_1 < \operatorname{re}(s) < c_1; \quad \det A^t = \det A$$

Note that these abbreviations can be capitalized or lower case, according to the preference of the author.

4.16. Symbols in Sequence

Space between symbols in sequence, whether or not they are enclosed within parentheses.

... values of x, y, z

f(x, y, z) = z

4.17. Points of Omission

Space before and after points of omission, but do not space bet the points. Do not space before a comma following points of omissi-

$$p'_r = p_r, \ \cdots, \ p'_{j+1}$$

$$c_1 = c_2 = \cdots = c_k = 0$$

$$c_1 v_1 + c_2 v_2 + \cdots + c_k v_k$$

$$q'_{r-1} > q'_{r-2} > \cdots > q'_{i+1} \geq q'_i$$

$$j_3 = \cdots \ j_m = n + 1$$

4.18. Fractions (See also Secs. 3.1 and 3.2.)

Space before and after a built-up fraction.

$$\frac{\partial z}{\partial y} = g_y = -\frac{\phi_y}{\phi_z}; \qquad e^x = \sum_{k=0}^{n} x \frac{k}{k!} \div R_n; \qquad \frac{\partial z}{\partial r} = \frac{\partial z}{\partial x}\frac{\partial x}{\partial r} + \frac{\partial z}{\partial y}\frac{\partial y}{\partial r}$$

$$(1 - x^2)\frac{d^2 P_n}{dx^2} - 2x\frac{dP_n}{dx} + n(n+1)P_n = 0$$

$$y = e_w^x = \frac{x^3}{3}e^x + \frac{x^2}{2}c_1 e^x + c_2 e^x$$

Do not insert space between a small fraction and a following symbol (except before a radical sign; see Sec. 4.8).

$$\frac{\sin (n + \frac{1}{2})x}{2 \sin \frac{1}{2}x} = \frac{1}{2} + \sum_{k=1}^{n} \cos kx \quad \underline{\text{but}} \quad k_{i_{sT}} = \frac{\frac{1}{2} k_{i_{s1}} V_{R_1} \frac{b}{2} + \frac{1}{2} k_{i_{s2}} V_{R_2}}{\frac{1}{2}(V_{R_1} + V_{R_2})\frac{b}{2}}$$

4.19. Units of Measure in Displayed Equations

Allow three spaces between a displayed equation and a following unit of measure.

$$\lambda = 1300 + 30W + 3W^2 \quad \text{ft}$$

$$K = \frac{1}{2c} \frac{\omega_p^2 \nu}{\omega^2} \quad \text{nepers/unit distance}$$

$$P = \int \mu \, dh = \int \left(1 - \frac{\omega_p^2}{\omega^2}\right)^{\frac{1}{2}} dh \quad \text{units of } h$$

$$\Delta A \approx \frac{\sec i}{f_{Mc}^2} \frac{\Delta N_{max} \, T_{kev}^3}{10} \quad \text{decibels per layer transit}$$

4.20. Connecting Words and Phrases in Displayed Equations

Allow three spaces before and after "and," "or," "as," "whenever," "if," "for," and "where" when they join two equations.

$$x - x_0 = h \quad \text{and} \quad y - y_0 = k$$

$$e^w - e^{-w} = 2z \quad \text{or} \quad e^{2w} - 2ze^w - 1 = 0$$

$$f(x, y) \to L \quad \text{as} \quad (x, y) \to (a, b)$$

$$|u_k(t) - u_k(s)| \leq \epsilon \quad \text{whenever} \quad |t - s| \leq \delta$$

$$\phi(i, \alpha, 0) = 0 \quad \text{if} \quad i \neq L$$

$$p_{j0} = 0 \quad \text{for} \quad j < L$$

$$\ln w = \ln r + i\theta \quad \text{where} \quad w = re^{i\theta}$$

Allow three spaces before and only one space after these words when they are immediately followed by another word or words.

$$|u_{mn} - L| < \epsilon \quad \text{whenever both } m > N \text{ and } n > N$$

$$|f_n(t) - f(t)| < \frac{\epsilon}{L} \quad \text{for all } n > N \text{ and all } t \text{ on } I$$

$$f_0(x) = \begin{cases} f(x) & \text{for } -\pi < x < \pi, \\ f_0(x - 2\pi) & \text{for all other } x \end{cases}$$

Note that in a braced equation, the explanatory expressions are alig three spaces being allowed before the expression for the longest

4.21. Defining Expressions

In text, allow one space before a defining expression, whether c not the expression is enclosed within parentheses. In a displayed equation, allow five spaces before the defining expression.

$$\ldots \text{ given } Y_j - Y_0,\ j = 1, \ldots, k \qquad \text{(in text)}$$

$$L(x + y) - L(x) \leq 1 + L(y), \qquad x, y > 0$$

$$EX_i = 0, \qquad i = 1, 2, \ldots$$

$$f_{ii}s_{i\gamma} = 0, \qquad i = 1, \ldots, p;\ \gamma = p + 1, \ldots, n$$

In a braced equation, align the defining expressions; allow only thre spaces before the defining expression for the longest element.

$$f(x) = \begin{cases} x^{-1}g_1(x^{-\alpha}), & x > 0, \\ x^{-1}g_2(|x|^{-\alpha}), & x < 0 \end{cases}$$

If the principal equation is too long to permit the defining expression to be placed on the same line, it should be placed on the line immediately following the principal equation, flush right if the equation is unnumbered. (If the equation is numbered, place the defining expression four spaces from the equation number. See Sec. 5.8.)

$$L(u) = a_0 u'(t) + b_0 u(t) + b_1 u(t - \omega) + \int_{\alpha}^{\beta} b(t_1) u(t - t_1)\, dt_1,$$

$$0 < \alpha,\ \alpha \leq \omega,\ \alpha \leq \beta$$

4.22. Displayed Equations (See also Sec. 5.)

Triple-space before and after a displayed equation and between multiple equations (disregarding inferiors and superiors), unless the equations are complex, in which case the spacing must be adjusted as necessary.

$$u_{xx} + u_{yy} = f(u, x, y)$$

$$u_t - u_{xx} = f(u, x, y)$$

$$s(x) = \int_0^x p(s) \exp\left[2 \int_0^x v(t)\, dt\right] ds$$

$$y^2 = r^2 + \frac{4\rho^2}{\left(\frac{1}{c^4} - \rho^2\right)^2} - \frac{4r\left(\frac{1}{c^2} - \frac{1}{r}\right)}{\frac{1}{c^4} - \rho^2}$$

Triple-space between the lines of a multiline displayed equation (disregarding inferiors and superiors). If the equation is complex,

the spacing will have to be adjusted as necessary (see also Sec. 5.4.

$$v(t, t)u(t) - v(\omega, t)g(\omega) - \int_{\omega}^{t} \frac{\partial v(s, t)}{\partial s} u(s)\, ds + \int_{\omega}^{t} v(s, t)a(s)u(s)\, ds + \int_{\omega}^{t} v(s, t)b(s)u(s - \omega)\, ds = 0$$

5. ARRANGEMENT OF EQUATIONS

5.1. Placement of a Single-line Displayed Equation

Center a single-line equation (including its defining expression; see Sec. 4.21) on the full text width.

$$\frac{d^2y}{dx^2} + g(x)y = 0, \qquad 0 \le x \le b \tag{1}$$

5.2. Placement of a Multiline Displayed Equation (See also Sec. 5.4.)

When a displayed equation occupies more than one line, center the entire equation on the text width.

$$\begin{aligned} u(t) = a_0 g(\beta) k(t - \beta) - b_1 \int_{\beta-\omega}^{\beta} k(t - \omega - t_1) g(t_1)\, dt_1 \\ + \int_{\alpha}^{\beta} b(t_1)\, dt_1 \int_{\beta-t_1}^{\beta} k(t - t_1 - t_2) g(t_2)\, dt_2 \\ + \int_{\beta}^{t} f(t_1) k(t - t_1)\, dt_1, \qquad t > \beta \end{aligned} \tag{1}$$

5.3. Placement of Multiple Single-line Displayed Equations

When several single-line equations are displayed, they should, if possible, be aligned on an equality or inequality sign and the entire group centered on the text width.

$$\sin \lambda_1 = A_x, \tag{1}$$

$$\cos \lambda_1 = \sqrt{A_x^2 + A_y^2}, \tag{2}$$

$$\cos (\beta_1 - \beta_0) = \frac{A_x}{\cos \lambda_1}, \tag{3}$$

$$\sin (\beta_1 - \beta_0) = \frac{A_y}{\cos \lambda_1} \tag{4}$$

However, when alignment would be awkward, each equation should be centered separately on the text width.

$$\frac{\partial f}{\partial T} = g(c_1 v) + v \frac{\partial f}{\partial c},$$

$$\frac{\partial}{\partial c}(g - v g_v) = -\frac{\partial}{\partial T}(gv),$$

$$g_c + g_v v_c - v_c g_v - v g_{vv} - v g_{vc} = -g_{vv} v_T$$

Several short equations can be placed on the same line, provi the equations are unnumbered or all have the same equation number. Allow four spaces between these equations.

$$R = R_0, \qquad \frac{dR}{dt} = V_0 \sin \gamma_0, \qquad \frac{d\theta}{dt} = \frac{V_0 \cos \gamma_0}{R_0}$$

Several equations can be grouped and centered on the text wi

$$u_1'(t) = g(v_1), \qquad u_1(0) = v_1,$$

$$u_2'(t) = g(u_1(t)), \qquad u_2(0) = u_1(1)$$

$$u'' - u - \sum_{k=1}^{R} v_k u = 0, \qquad u(0) = c_1, \qquad u'(0) = c_2,$$

$$v_k' + \lambda_k v_k = 0, \qquad v_k(0) = z_k$$

Note that when the equation number applies to the entire group, it centered on the two lines. (See also Sec. 5.8.)

5.4. Placement of Multiple Multiline Displayed Equations

Whenever possible, complex equations should be aligned and the entire group centered on the text width.

$$\frac{1}{4}\frac{dF_1(\tau)}{d\tau} = J_1(\tau)[1 - \omega(\tau)] + \frac{1}{4}\omega(\tau)\Big\{3K_1(\tau) - J_r(\tau) - e^{-\tau/\mu_0}\Big[\Big(1 - \frac{3}{4}\mu_0^2\Big)F_1(0) + \frac{1}{4}F_r(0)\Big]\Big\}, \quad (1)$$

$$\frac{1}{4}\frac{dF_r(\tau)}{d\tau} = J_r(\tau) + \frac{1}{4}\omega(\tau)\Big\{-3K_1(\tau) - 3J_r(\tau) - e^{-\tau/\mu_0}\frac{3}{4}[\mu_0^2F_1(0) + F_r(0)]\Big\}, \quad (2)$$

$$\frac{1}{4}\frac{d}{d\tau}[F_1(\tau) + F_r(\tau)] = [1 - \omega(\tau)][J_1(\tau) + J_r(\tau)] - \frac{1}{4}\omega(\tau)e^{-\tau/\mu_0}[F_1(0) + F_r(0)] \quad (3)$$

However, if alignment would present an awkward arrangement, each equa should be centered seperately on the text width.

$$-\frac{\partial S^{*(m)}}{\partial\tau_0} + \Big(\frac{1}{\mu} + \frac{1}{\mu_0}\Big)S^{*(m)} = \omega(\tau_0)(2 - \delta_{0m})\sum_{i=m}^{n}(-1)^{i+m} \times k_{im}(\tau_0)\psi_i^m(\tau_0;\mu)\psi_i^m(\tau_0;\mu_0), \quad (1)$$

$$S^{*(m)}(\tau_0;\mu,\mu_0) = (2 - \delta_{0m})\int_{\tau_0}^{\tau_1}\omega(t) \times \sum_{i=m}^{n}k_{im}(t)\psi_i^{*m}(t,\mu_0) \times \exp\Big[-(t - \tau_0)\Big(\frac{1}{\mu} + \frac{1}{\mu_0}\Big)\Big]dt \quad (2)$$

5.5. Breaking Equations and Expressions in a Text Line

In a text line, an equation should be broken, if possible, on an equality or inequality sign (see Sec. 4.3).

Show that $h_n(x) = f_n(x)g_n(x)$ converges on I to $h(x) = f(x)g(x)$.

This definition holds for relative minimum when $f(x, y) \geq f(x_o, y_0)$ is satisfied.

It is easy to verify that $v = 0$ for all (x, y, z) when $(x, y) \neq (0, 0)$.

Note that it is preferable to type the equality or inequality sign on the line preceding the broken portion.

If necessary, an equation may be broken on a sign of operation (s- Sec. 4.2).

Setting $c = 1$ and $d = -1$, we then obtain $0 \cdot v = 1 \cdot v + (-1) \cdot v$.

A relation between x and y is shown by $x^6 + 2y^8 = 7x^2y^2 - 8x + 2y = 0$.

By definition of a smooth surface element, we can see that $r_u \times r_v \neq 0$.

A sequence can be broken on a mark of punctuation if the elements are n enclosed within parentheses.

We can see that the set of linear combinations of $v_1, v_2, \ldots, v_k$ is the space spanned by the k vectors.

Since $v_1, v_2, \ldots, v_k$ are linearly dependent, we select $c_1, c_2, \ldots, c_k$.

Here F is considered as a function of the four variables x, y, z, λ.

Do not break between elements that are in a series enclosed within parentheses.

Incorrect: The corresponding element of range is $y = (y_1, y_2, \ldots, y_n)$.

Correct: The corresponding element of range is $y = (y_1, y_2, \ldots, y_n)$.

Correct: There is an orthonormal basis for space vectors $(x_1, x_2, x_3$ to satisfy the given systems of equations.

Do not break a simple equation at the end of a line (leave the line short if more than two characters are needed to complete the expression).

Incorrect: Solve for y as a function of x, since $F_y \neq 0$. When $x \neq -2$, solve for x as a function of y.

Correct: Solve for y as a function of x, since $F_y \neq 0$. When $x \neq -2$, solve for x as a function of y.

Do not separate a trigonometric function from its argument (see also Sec. 4.6).

Incorrect: If $s_p(x)$ converges uniformly to f(x), then $s_p(x)$ cos nx will converge to f(x) cos nx for each fixed n.

Correct: If $s_p(x)$ converges uniformly to f(x), then $s_p(x)$ cos nx will converge to f(x) cos nx for each fixed n.

Do not break an expression enclosed within parentheses (for displayed equations, see Sec. 5.6).

Incorrect: Show that f may be written as $f(x) = a_0 + a_1(x - 1) + a_2(x - 1)^2 + a_3(x - 1)^3 + a_4(x - 1)^4$.

Correct: Show that f may be written as $F(x) = a_0 + a_1(x - 1) + a_2(x - 1)^2 + a_3(x - 1)^3 + a_4(x - 1)^4$.

Do not break an expression that is enclosed within vertical bars (see also Secs. 4.1 and 4.9).

Incorrect: We conclude that the series converges and that $|f($

$f(x_0)| \leq |x - x_0| \cdot K.$

Correct: We conclude that the series converges and that

$|f(x) - f(x_0)| \leq |x - x_0| \cdot K.$

Do not break an equation between an integral $(\int)$ or summation and the terms governed by these symbols.

Incorrect: For any function f, we see that $\int_a^b f(x)\,dx = \int_a^b f_1$

$dx + i \int_a^b f_2(x)\,dx.$

Correct: For any function f, we see that $\int_a^b f(x)\,dx = \int_a^b f_1$

$i \int_a^b f_2(x)\,dx.$

Incorrect: It follows that the series is convergent since $\sum_k^\infty$

$1/k^2 = M < \infty.$

Correct: It follows that the series is convergent since $\sum_1^\infty$

$M < \infty.$

5.6. Breaking and Aligning Displayed Equations

A displayed equation should be broken, if possible, on an equa or inequality sign. Align the equality or inequality signs.

$$J(\tau) = \frac{1}{6}\int_0^{\tau_1}\left[\int_0^1 M(\mu)e^{-|\tau-t|\mu}\,\frac{d\mu}{\mu}\right] \cdot J^{(0)}(t, \mu_0)\omega(t)\,dt$$

$$= \frac{1}{6}\int_0^{\tau_1} G^{(1)}(|\tau - t|) \cdot J^{(0)}(t, \mu_0)\omega(t)\,dt,$$

$$V^0(x_0, t_0) - V^0(x_1, t_1) = \int_{t_0}^{t_1} [L(x, k(x, t), t) + \varepsilon(x, t)]\,dt$$

$$> \int_{t_0}^{t_1} L(x, k(x, t), t)\,dt$$

A displayed equation can also be broken on a sign of operatio signs of operation are aligned one space in back of the equality or sign.

$$p_2(s) = -b_1 g(\beta - \omega)e^{-\beta s} - b_0 g(\beta)e^{-\beta s} + (a_0 s + b_0)\int_0^{\beta} e^{-st} g^1(t)\,dt$$
$$+ b_1 e^{-\omega s}\int_0^{\beta-\omega} e^{-st} g^1(t)\,dt + e^{-\beta s}\int_{\alpha}^{\beta} b(t_1) g(\beta - t_1)\,dt_1$$
$$- \int_{\alpha}^{\beta} e^{-st_1} b(t_1)\,dt_1 \int_0^{\beta - t_1} e^{-st} g^1(t)\,dt, \qquad (1)$$

$$\int_0^t v(t-s)\phi(s)\,ds = f(0)\int_0^t \mu(t-s)\phi(s)\,ds$$
$$+ \int_0^t [\mu(t-s) - 1]f'(s)\,ds$$
$$= f(0)\mu(t) - f(0) + \int_0^t \mu(t-s)f'(s)\,ds$$
$$- \int_0^t f'(s)\,ds$$
$$= f(0)\mu(t) - f(t) + \int_0^t \mu(t-s)f'(s)\,ds$$
$$= v(t) - f(t) \qquad (2)$$

A two-line equation can be staggered rather than aligned. Center the whole equation, making certain that the lines overlap.

$$\mu'(t) = -b_0 a_0^{-1} \sum_{r=1}^{\infty} \exp(s_r t)p_r(t)$$
$$\cdot\, b_1 a_0^{-1} \sum_{r=1}^{\infty} \exp[s_r(t-\omega)]p_r(t-\omega)$$

If a displayed equation is broken on a sign of multiplication (which is understood but usually not present), the multiplication sign is placed at the beginning of the new line.

$$I(z_1, x, t; +\mu) = I(z_1, x, t; +\mu; I_{inc})$$
$$= \tfrac{1}{2}\int_{-\infty}^{\infty}\int_0^t\int_0^1 R(z_1, x - x', t - t'; \mu, \mu')$$
$$\times I_{inc}(z_1, x', t'; -\mu')dx'\,dt'\,du',$$

If possible, do not break an expression enclosed within grouping symbols (see Sec. 2.7). When such a break cannot be avoided, try to break within a major grouping symbol.

$$\Delta(E - E_0) = \frac{a}{r}\{\Delta(M - M_0) + \sin(E - E_0)\Delta(e\cos E_0) - [1 - \cos(E - E_0)]\Delta(e \sin E_0)\}, \quad (1)$$

$$\mu(t) = \frac{1}{2\pi i}\lim_{\ell\to\infty}\left[\int_{c_{\ell-}} e^{st}h^{-1}(s)p_a(s)\,ds + \int_{c_{\ell+}} e^{st}h^{-1}(s)p_b(s)\,ds - \int_{c_\ell} e^{st}h^{-1}(s)p_v(s)\,ds\right] \quad (2)$$

5.7. Alignment of Symbols Following "Where"

When the symbols used in a displayed equation are defined and pr by the word "where," type the first symbol on the same line as the wo "where" and align the remaining symbols on the right of the first sy including the subscripts.

$$V = \tfrac{1}{2}J_{n_s} n_f W_g,$$

where V = total shear,

J_{n_s} = reduction factor for shear,

n_f = ultimate flight load factor,

W_g = gross weight.

Note that the word "where" is typed flush left and that there is only space between it and the first symbol.

When the definition is in the form of an equation, display and c it.

$$h = h_R(1 - K_1 n),$$

where

$$K_1 = 1 - \frac{h_T}{h_R}$$

5.8. Numbering Displayed Equations

Equation numbers may be typed flush right or flush left, according to the preference of the author. Allow a minimum of four spaces between an equation and its number.

If the equations are numbered on the left, type the number on the first line of both a single-line and a multiline equation.

(1) $$T_1 w(r) \le -\alpha e^{-r},$$

(2) $$T_1 0(r) = \alpha e^{-r} - e^{-r} \int_0^r e^{2t}\, dt \times \int_t^\infty e^{-s}[\phi(-\alpha, s) + \alpha]\, ds \ge -\alpha e^{-r} - e^{-r} \int_0^r e^{2t}\, dt \int_t^\infty e^{-s}\alpha\, ds$$

If the equations are numbered on the right, type the number on the same line as a single-line equation and on the last line of a multiline equation.

$$T_1 w(r) \le -\alpha e^{-r}, \tag{1}$$

$$T_1 0(r) = -\alpha e^{-r} - e^{-r} \int_0^r e^{2t}\, dt \int_t^\infty e^{-s}[\phi(-\alpha, s) + \alpha]\, ds \ge -\alpha e^{-r} - e^{-r} \int_0^r e^{2t}\, dt \int_t^\infty e^{-s}\alpha\, ds \tag{2}$$

If the equation is too long to permit the number to be typed on the same line, type it on the line immediately following.

$$|p(t)| \le c_2 e^{-\lambda t_0} m(t) e^{kt} \int_{t_0}^t |a(t_1)| \exp\left[(\lambda - k)t_1 - c_1 \int_{t_0}^{t_1} a(t_2)\, dt_2\right] dt_1 \tag{1}$$

When an equation number applies to two or more equations, it should be centered between the equations.

$$J_1(t) = \int_{t_0}^{t} a(t_1)u(t_1) \exp [\lambda(t - t_1)] \, dt_1,$$
$$J_2(t) = \int_{t_0}^{t} a(t_1)u(t_1)k_1(t - t_1) \, dt_1 \qquad (1)$$

If two or more equations are grouped within a brace, the equation number should center on the brace.

$$\left.\begin{aligned} B_1\sigma - \frac{\sigma}{D} + a_1(\sigma - \sigma_1) &= 0, \\ B\sigma_1 - a_\sigma(\sigma - \sigma_1) &= 0 \end{aligned}\right\} \qquad (1)$$

If the principal equation is too long to permit the defining expressio (see Sec. 4.21) and the equation number to be placed on the line with it, either (1) type the defining expression on the same line as the principal equation and type the equation number on the line immediately following, or (2) type both the defining expression and the equation number on the line immediately following.

$$\int_{t_0}^{t} v(s, t)b(s)u(s) \, ds = \int_{t_0}^{t-h} v(s + h, t)b(s + h)u(s + h) \, ds, \qquad t > t_0 \qquad (1)$$

$$\int_{t_0}^{t} v(s, t)b(s)u(s) \, ds = \int_{t_0}^{t-h} v(s + h, t)b(s + h)u(s + h) \, ds, \qquad t > t_0 \qquad (2)$$

Appendix A

MATHEMATICAL TERMS AND SYMBOLS

Absolute value or magnitude	$\lvert\ \rvert$
Adjoint	adj
Approaches	$\rightarrow$ or $\doteq$
Approximately equals	$\simeq$ or $\sim$
Argument	arg
Aspect ratio	AR
Boundary of	∂
Braces	$\{\ \}$
Brackets	$[\ ]$
Change in	Δ
Constant	const
Contains (or includes)	$\supset$ or $\supseteq$
Cosecant	csc
Cosine	cos
Cotangent	cot
Cube root	$\sqrt[3]{\ }$
Degree	$^\circ$
Difference	$\sim$
Divergence	div
Divided by	$\div$
Equal to	$=$
Exponential	exp
Greater or less than	$\gtrless$
Greater than	$>$

Greater than or equal to	$\geq$
Greatest lower bound	g.l.b. or inf
Factorial	!
Hence, therefore	$\therefore$
Included in (or contained in)	$\subset$ or $\subseteq$
Identical with	$\equiv$
Increment of	Δ
Infimum	inf
Infinity	∞
Integral	$\int$
Intersection	$\cap$
Is a member of	ϵ
Least upper bound	l.u.b. or sup
Less than	$<$
Less than or equal to	$\leq$
Less than or greater than	$\lessgtr$
Limit	lim
Limit inferior	lim inf
Limit of integration	$\Big\vert$
Limit superior	lim sup
Logarithm	log
Magnitude or absolute value	$\vert\ \vert$
Maximum	max
Minimum	min
Minus	-
Minus or plus	$\mp$
Minute	$'$

Much greater than	$\gg$
Much smaller than	$\ll$
Multiplied by	$\times$ or $\cdot$
Nearly equal to	$\approx$
Norm	$\| \ \|$
Not equal to	$\neq$
Not greater than	$\not>$
Not included in	$\notin$
Not less than	$\not<$
Parallel to	$\parallel$
Parentheses	( )
Partial differential	∂
Perpendicular to	$\perp$
Plus	+
Plus or minus	$\pm$
Product	$\prod$
Radical	$\surd$
Ratio of	:
Secant	sec
Second	$''$
Sine	sin
Solidus	/
Such that	|
Summation	$\sum$
Supremum	sup
Tangent	tan
Triangle	Δ

Union	$\cup$
Variation	$\propto$
Vector	arrow above symbol or symbol print in bold type
Versed sine	vers

Appendix B

GREEK ALPHABET

Greek Name	English Equivalent	Greek Letter			
		Capitals		Lower Case	
		Typit	Script	Typit	Script
Alpha	a	A	A	α	α
Beta	b	B	B	β	β
Gamma	g	Γ	Γ	γ	γ
Delta	d	Δ	Δ	δ	δ
Epsilon	ĕ	E	E	ε	ε
Zeta	z	Z	Z	ζ	ζ
Eta	ē	H	H	η	η
Theta	th	Θ	Θ	θ	θ
Iota	i	I	I	ι	ι
Kappa	k	K	K	κ	κ
Lambda	l	Λ	Λ	λ	λ
Mu	m	M	M	μ	μ
Nu	n	N	N	ν	ν
Xi	x	Ξ	Ξ	ξ	ξ
Omicron	ŏ	O	O	ο	ο
Pi	p	Π	Π	π	π
Rho	r	P	P	ρ	ρ
Sigma	s	Σ	Σ	σ	σ
Tau	t	T	T	τ	τ
Upsilon	u	Y	T	υ	υ
Phi	ph	Φ	Φ	φ or ϕ	ϕ
Chi	ch	X	X	χ	χ
Psi	ps	Ψ	Ψ	ψ	ψ
Omega	ō	Ω	Ω	ω	ω

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