

# 1 Sebastian's math test

The default math mode font is *Math Italic*. This should not be confused with ordinary *Text Italic* – notice the different spacing! `\mathbf` produces bold roman letters: **abcABC**. If you wish to embolden complete formulas, use the `\boldmath` command *before* going into math mode. This changes the default math fonts to bold.

normal  $x = 2\pi \Rightarrow x \simeq 6.28$   
mathbf  $\mathbf{x} = 2\pi \Rightarrow \mathbf{x} \simeq 6.28$   
boldmath  $\mathbf{x} = 2\pi \Rightarrow \mathbf{x} \simeq 6.28$

Greek is available in upper and lower case:  $\alpha, \beta \dots \Omega$ , and there are special symbols such as  $\hbar$  (compare to  $h$ ). Digits in formulas  $1, 2, 3 \dots$  may differ from those in text: 4, 5, 6...

There is Sans Serif alphabet abcdeABCD selected by `\mathsf` and Type-writer math abcdeABCD selected by `\mathtt`.

There is a calligraphic alphabet `\mathcal` for upper case letters  $\mathcal{A}\mathcal{B}\mathcal{C}\mathcal{D}\mathcal{E} \dots$ , and there are letters for number sets:  $\mathbb{A} \dots \mathbb{Z}$ , which are produced using `\mathbb`. There are Fraktur letters abcde $\mathfrak{A}\mathfrak{B}\mathfrak{C}\mathfrak{D}\mathfrak{E}$  produced using `\mathfrak`

$$\sigma(t) = \frac{1}{\sqrt{2\pi}} \int_0^t e^{-x^2/2} dx \tag{1}$$

$$\prod_{j\geq 0}\left(\sum_{k\geq 0}a_{jk}z^k\right)=\sum_{k\geq 0}z^n\left(\sum_{\substack{k_0,k_1,\dots\geq 0\\k_0+k_1+\dots=n}}a_0k_0a_{1k_1}\dots\right) \tag{2}$$

$$\pi(n)=\sum_{m=2}^n\left[\left(\sum_{k=1}^{m-1}\lfloor(m/k)/\lceil m/k\rceil\right)^{-1}\right] \tag{3}$$

$$\overbrace{\{a,\dots,a,b,\dots,b\}}^{k\text{ }a\text{'s}\quad l\text{ }b\text{'s}} \tag{4}$$

$k+l$  elements

$$\begin{array}{l} \nearrow \mu^+ + \nu_\mu \\ \rightarrow \pi^+ + \pi^0 \\ \mathbf{W}^+ \\ \rightarrow \kappa^+ + \pi^0 \\ \searrow \mathrm{e}^+ + \nu_{\mathrm{e}} \end{array}$$

$$\pm \left| \begin{array}{ccc} x_1-x_2 & y_1-y_2 & z_1-z_2 \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{array} \right|$$


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$$\sqrt{\left| \begin{array}{cc} l_1 & m_1 \\ l_2 & m_2 \end{array} \right|^2 + \left| \begin{array}{cc} m_1 & n_1 \\ n_1 & l_1 \end{array} \right|^2 + \left| \begin{array}{cc} m_2 & n_2 \\ n_2 & l_2 \end{array} \right|^2}$$

## 2 Math Tests

Math test are taken from[1].

### 2.1 Math Alphabets

Math Italic (`\mathnormal`)

*A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z,*  
*a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z, \iota, j,*  
*A, B, \Gamma, \Delta, E, Z, H, \Theta, I, K, \Lambda, M, N, \Xi, O, \Pi, P, \Sigma, T, \Upsilon, \Phi, X, \Psi, \Omega,*  
*\alpha, \beta, \gamma, \delta, \epsilon, \zeta, \eta, \theta, \iota, \kappa, \lambda, \mu, \nu, \xi, o, \pi, \rho, \sigma, \tau, \upsilon, \phi, \chi, \psi, \omega, \varepsilon, \vartheta, \varpi, \varrho, \varsigma, \varphi, \ell, \wp,*

Math Roman (`\mathrm`)

0, 1, 2, 3, 4, 5, 6, 7, 8, 9,  
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z,  
a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z, *\iota, j*,  
A, B, \Gamma, \Delta, E, Z, H, \Theta, I, K, \Lambda, M, N, \Xi, O, \Pi, P, \Sigma, T, \Upsilon, \Phi, X, \Psi, \Omega,  
*\alpha, \beta, \gamma, \delta, \epsilon, \zeta, \eta, \theta, \iota, \kappa, \lambda, \mu, \nu, \xi, o, \pi, \rho, \sigma, \tau, \upsilon, \phi, \chi, \psi, \omega, \varepsilon, \vartheta, \varpi, \varrho, \varsigma, \varphi, \ell, \wp,*

Math Bold (`\mathbf`)

**0, 1, 2, 3, 4, 5, 6, 7, 8, 9,**  
**A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z,**  
**a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z, \iota, j,**

Math Sans Serif (`\mathsf`)

0, 1, 2, 3, 4, 5, 6, 7, 8, 9,  
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z,  
a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z, *\iota, j*,

Caligraphic (`\mathcal`)

*A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z,*

Fraktur (`\mathfrak`)

*\mathfrak{A}, \mathfrak{B}, \mathfrak{C}, \mathfrak{D}, \mathfrak{E}, \mathfrak{F}, \mathfrak{G}, \mathfrak{H}, \mathfrak{I}, \mathfrak{J}, \mathfrak{K}, \mathfrak{L}, \mathfrak{M}, \mathfrak{N}, \mathfrak{O}, \mathfrak{P}, \mathfrak{Q}, \mathfrak{R}, \mathfrak{S}, \mathfrak{T}, \mathfrak{U}, \mathfrak{V}, \mathfrak{W}, \mathfrak{X}, \mathfrak{Y}, \mathfrak{Z},*  
*\mathfrak{a}, \mathfrak{b}, \mathfrak{c}, \mathfrak{d}, \mathfrak{e}, \mathfrak{f}, \mathfrak{g}, \mathfrak{h}, \mathfrak{i}, \mathfrak{j}, \mathfrak{k}, \mathfrak{l}, \mathfrak{m}, \mathfrak{n}, \mathfrak{o}, \mathfrak{p}, \mathfrak{q}, \mathfrak{r}, \mathfrak{s}, \mathfrak{t}, \mathfrak{u}, \mathfrak{v}, \mathfrak{w}, \mathfrak{x}, \mathfrak{y}, \mathfrak{z}, \mathfrak{i}, \mathfrak{j},*

Blackboard Bold (`\mathbb`)

A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z,

## 2.2 Character Sidebearings

$|A| + |B| + |C| + |D| + |E| + |F| + |G| + |H| + |I| + |J| + |K| + |L| + |M| +$   
 $|N| + |O| + |P| + |Q| + |R| + |S| + |T| + |U| + |V| + |W| + |X| + |Y| + |Z| +$   
 $|a| + |b| + |c| + |d| + |e| + |f| + |g| + |h| + |i| + |j| + |k| + |l| + |m| +$   
 $|n| + |o| + |p| + |q| + |r| + |s| + |t| + |u| + |v| + |w| + |x| + |y| + |z| + |ı| + |j| +$   
 $|A| + |B| + |Γ| + |Δ| + |E| + |Z| + |H| + |Θ| + |I| + |K| + |Λ| + |M| +$   
 $|N| + |Ξ| + |O| + |Π| + |P| + |Σ| + |T| + |Υ| + |Φ| + |X| + |Ψ| + |Ω| +$   
 $|α| + |β| + |γ| + |δ| + |ε| + |ζ| + |η| + |θ| + |ι| + |κ| + |λ| + |μ| +$   
 $|ν| + |ξ| + |ο| + |π| + |ρ| + |σ| + |τ| + |υ| + |φ| + |χ| + |ψ| + |ω| +$   
 $|ε| + |ϑ| + |Ϙ| + |ϙ| + |ς| + |φ| + |ℓ| + |Ϙ| +$

$|A| + |B| + |C| + |D| + |E| + |F| + |G| + |H| + |I| + |J| + |K| + |L| + |M| +$   
 $|N| + |O| + |P| + |Q| + |R| + |S| + |T| + |U| + |V| + |W| + |X| + |Y| + |Z| +$   
 $|a| + |b| + |c| + |d| + |e| + |f| + |g| + |h| + |i| + |j| + |k| + |l| + |m| +$   
 $|n| + |o| + |p| + |q| + |r| + |s| + |t| + |u| + |v| + |w| + |x| + |y| + |z| + |ı| + |j| +$   
 $|A| + |B| + |Γ| + |Δ| + |E| + |Z| + |H| + |Θ| + |I| + |K| + |Λ| + |M| +$   
 $|N| + |Ξ| + |O| + |Π| + |P| + |Σ| + |T| + |Υ| + |Φ| + |X| + |Ψ| + |Ω| +$

$|A| + |B| + |C| + |D| + |E| + |F| + |G| + |H| + |I| + |J| + |K| + |L| + |M| +$   
 $|N| + |O| + |P| + |Q| + |R| + |S| + |T| + |U| + |V| + |W| + |X| + |Y| + |Z| +$

### 2.3 Superscript positioning

$$\begin{aligned}
&A^2+B^2+C^2+D^2+E^2+F^2+G^2+H^2+I^2+J^2+K^2+L^2+M^2+ \\
&N^2+O^2+P^2+Q^2+R^2+S^2+T^2+U^2+V^2+W^2+X^2+Y^2+Z^2+ \\
&a^2+b^2+c^2+d^2+e^2+f^2+g^2+h^2+i^2+j^2+k^2+l^2+m^2+ \\
&n^2+o^2+p^2+q^2+r^2+s^2+t^2+u^2+v^2+w^2+x^2+y^2+z^2+ \\
&A^2+B^2+\Gamma^2+\Delta^2+E^2+Z^2+H^2+\Theta^2+I^2+K^2+\Lambda^2+M^2+ \\
&N^2+\Xi^2+O^2+\Pi^2+P^2+\Sigma^2+T^2+\Upsilon^2+\Phi^2+X^2+\Psi^2+\Omega^2+ \\
&\alpha^2+\beta^2+\gamma^2+\delta^2+\epsilon^2+\zeta^2+\eta^2+\theta^2+\iota^2+\kappa^2+\lambda^2+\mu^2+ \\
&\nu^2+\xi^2+o^2+\pi^2+\rho^2+\sigma^2+\tau^2+v^2+\phi^2+\chi^2+\psi^2+\omega^2+ \\
&\varepsilon^2+\vartheta^2+\varpi^2+\varrho^2+\varsigma^2+\phi^2+\ell^2+\wp^2+
\end{aligned}$$

$$\begin{aligned}
&A^2+B^2+C^2+D^2+E^2+F^2+G^2+H^2+I^2+J^2+K^2+L^2+M^2+ \\
&N^2+O^2+P^2+Q^2+R^2+S^2+T^2+U^2+V^2+W^2+X^2+Y^2+Z^2+ \\
&a^2+b^2+c^2+d^2+e^2+f^2+g^2+h^2+i^2+j^2+k^2+l^2+m^2+ \\
&n^2+o^2+p^2+q^2+r^2+s^2+t^2+u^2+v^2+w^2+x^2+y^2+z^2+ \\
&A^2+B^2+\Gamma^2+\Delta^2+E^2+Z^2+H^2+\Theta^2+I^2+K^2+\Lambda^2+M^2+ \\
&N^2+\Xi^2+O^2+\Pi^2+P^2+\Sigma^2+T^2+\Upsilon^2+\Phi^2+X^2+\Psi^2+\Omega^2+
\end{aligned}$$

$$\begin{aligned}
&\mathcal{A}^2+\mathcal{B}^2+\mathcal{C}^2+\mathcal{D}^2+\mathcal{E}^2+\mathcal{F}^2+\mathcal{G}^2+\mathcal{H}^2+\mathcal{I}^2+\mathcal{J}^2+\mathcal{K}^2+\mathcal{L}^2+\mathcal{M}^2+ \\
&\mathcal{N}^2+\mathcal{O}^2+\mathcal{P}^2+\mathcal{Q}^2+\mathcal{R}^2+\mathcal{S}^2+\mathcal{T}^2+\mathcal{U}^2+\mathcal{V}^2+\mathcal{W}^2+\mathcal{X}^2+\mathcal{Y}^2+\mathcal{Z}^2+
\end{aligned}$$

## 2.4 Subscript positioning

$$\begin{aligned}
&A_i + B_i + C_i + D_i + E_i + F_i + G_i + H_i + I_i + J_i + K_i + L_i + M_i + \\
&N_i + O_i + P_i + Q_i + R_i + S_i + T_i + U_i + V_i + W_i + X_i + Y_i + Z_i + \\
&a_i + b_i + c_i + d_i + e_i + f_i + g_i + h_i + i_i + j_i + k_i + l_i + m_i + \\
&n_i + o_i + p_i + q_i + r_i + s_i + t_i + u_i + v_i + w_i + x_i + y_i + z_i + \iota_i + j_i + \\
&A_i + B_i + \Gamma_i + \Delta_i + E_i + Z_i + H_i + \Theta_i + I_i + K_i + \Lambda_i + M_i + \\
&N_i + \Xi_i + O_i + \Pi_i + P_i + \Sigma_i + T_i + \Upsilon_i + \Phi_i + X_i + \Psi_i + \Omega_i + \\
&\alpha_i + \beta_i + \gamma_i + \delta_i + \epsilon_i + \zeta_i + \eta_i + \theta_i + \iota_i + \kappa_i + \lambda_i + \mu_i + \\
&\nu_i + \xi_i + o_i + \pi_i + \rho_i + \sigma_i + \tau_i + \upsilon_i + \phi_i + \chi_i + \psi_i + \omega_i + \\
&\varepsilon_i + \vartheta_i + \varpi_i + \varrho_i + \varsigma_i + \phi_i + \ell_i + \wp_i +
\end{aligned}$$

$$\begin{aligned}
&A_i + B_i + C_i + D_i + E_i + F_i + G_i + H_i + I_i + J_i + K_i + L_i + M_i + \\
&N_i + O_i + P_i + Q_i + R_i + S_i + T_i + U_i + V_i + W_i + X_i + Y_i + Z_i + \\
&a_i + b_i + c_i + d_i + e_i + f_i + g_i + h_i + i_i + j_i + k_i + l_i + m_i + \\
&n_i + o_i + p_i + q_i + r_i + s_i + t_i + u_i + v_i + w_i + x_i + y_i + z_i + \iota_i + j_i + \\
&A_i + B_i + \Gamma_i + \Delta_i + E_i + Z_i + H_i + \Theta_i + I_i + K_i + \Lambda_i + M_i + \\
&N_i + \Xi_i + O_i + \Pi_i + P_i + \Sigma_i + T_i + \Upsilon_i + \Phi_i + X_i + \Psi_i + \Omega_i +
\end{aligned}$$

$$\begin{aligned}
&\mathcal{A}_i + \mathcal{B}_i + \mathcal{C}_i + \mathcal{D}_i + \mathcal{E}_i + \mathcal{F}_i + \mathcal{G}_i + \mathcal{H}_i + \mathcal{I}_i + \mathcal{J}_i + \mathcal{K}_i + \mathcal{L}_i + \mathcal{M}_i + \\
&\mathcal{N}_i + \mathcal{O}_i + \mathcal{P}_i + \mathcal{Q}_i + \mathcal{R}_i + \mathcal{S}_i + \mathcal{T}_i + \mathcal{U}_i + \mathcal{V}_i + \mathcal{W}_i + \mathcal{X}_i + \mathcal{Y}_i + \mathcal{Z}_i +
\end{aligned}$$

## 2.5 Accent positioning

$\hat{A} + \hat{B} + \hat{C} + \hat{D} + \hat{E} + \hat{F} + \hat{G} + \hat{H} + \hat{I} + \hat{J} + \hat{K} + \hat{L} + \hat{M} +$   
 $\hat{N} + \hat{O} + \hat{P} + \hat{Q} + \hat{R} + \hat{S} + \hat{T} + \hat{U} + \hat{V} + \hat{W} + \hat{X} + \hat{Y} + \hat{Z} +$   
 $\hat{a} + \hat{b} + \hat{c} + \hat{d} + \hat{e} + \hat{f} + \hat{g} + \hat{h} + \hat{i} + \hat{j} + \hat{k} + \hat{l} + \hat{m} +$   
 $\hat{n} + \hat{o} + \hat{p} + \hat{q} + \hat{r} + \hat{s} + \hat{t} + \hat{u} + \hat{v} + \hat{w} + \hat{x} + \hat{y} + \hat{z} + \hat{i} + \hat{j} +$   
 $\hat{A} + \hat{B} + \hat{\Gamma} + \hat{\Delta} + \hat{E} + \hat{Z} + \hat{H} + \hat{\Theta} + \hat{I} + \hat{K} + \hat{\Lambda} + \hat{M} +$   
 $\hat{N} + \hat{\Xi} + \hat{O} + \hat{\Pi} + \hat{P} + \hat{\Sigma} + \hat{T} + \hat{\Upsilon} + \hat{\Phi} + \hat{X} + \hat{\Psi} + \hat{\Omega} +$   
 $\hat{\alpha} + \hat{\beta} + \hat{\gamma} + \hat{\delta} + \hat{\epsilon} + \hat{\zeta} + \hat{\eta} + \hat{\theta} + \hat{i} + \hat{\kappa} + \hat{\lambda} + \hat{\mu} +$   
 $\hat{\nu} + \hat{\xi} + \hat{o} + \hat{\pi} + \hat{\rho} + \hat{\sigma} + \hat{\tau} + \hat{\upsilon} + \hat{\phi} + \hat{\chi} + \hat{\psi} + \hat{\omega} +$   
 $\hat{\varepsilon} + \hat{\vartheta} + \hat{\varpi} + \hat{\varrho} + \hat{\varsigma} + \hat{\phi} + \hat{\ell} + \hat{\wp} +$

$\hat{A} + \hat{B} + \hat{C} + \hat{D} + \hat{E} + \hat{F} + \hat{G} + \hat{H} + \hat{I} + \hat{J} + \hat{K} + \hat{L} + \hat{M} +$   
 $\hat{N} + \hat{O} + \hat{P} + \hat{Q} + \hat{R} + \hat{S} + \hat{T} + \hat{U} + \hat{V} + \hat{W} + \hat{X} + \hat{Y} + \hat{Z} +$   
 $\hat{a} + \hat{b} + \hat{c} + \hat{d} + \hat{e} + \hat{f} + \hat{g} + \hat{h} + \hat{i} + \hat{j} + \hat{k} + \hat{l} + \hat{m} +$   
 $\hat{n} + \hat{o} + \hat{p} + \hat{q} + \hat{r} + \hat{s} + \hat{t} + \hat{u} + \hat{v} + \hat{w} + \hat{x} + \hat{y} + \hat{z} + \hat{i} + \hat{j} +$

$\hat{\mathcal{A}} + \hat{\mathcal{B}} + \hat{\mathcal{C}} + \hat{\mathcal{D}} + \hat{\mathcal{E}} + \hat{\mathcal{F}} + \hat{\mathcal{G}} + \hat{\mathcal{H}} + \hat{\mathcal{I}} + \hat{\mathcal{J}} + \hat{\mathcal{K}} + \hat{\mathcal{L}} + \hat{\mathcal{M}} +$   
 $\hat{\mathcal{N}} + \hat{\mathcal{O}} + \hat{\mathcal{P}} + \hat{\mathcal{Q}} + \hat{\mathcal{R}} + \hat{\mathcal{S}} + \hat{\mathcal{T}} + \hat{\mathcal{U}} + \hat{\mathcal{V}} + \hat{\mathcal{W}} + \hat{\mathcal{X}} + \hat{\mathcal{Y}} + \hat{\mathcal{Z}} +$

## 2.6 Differentials

$$\begin{aligned}
& dA + dB + dC + dD + dE + dF + dG + dH + dI + dJ + dK + dL + dM + \\
& dN + dO + dP + dQ + dR + dS + dT + dU + dV + dW + dX + dY + dZ + \\
& da + db + dc + dd + de + df + dg + dh + di + dj + dk + dl + dm + \\
& dn + do + dp + dq + dr + ds + dt + du + dv + dw + dx + dy + dz + di + dj + \\
& dA + dB + d\Gamma + d\Delta + dE + dZ + dH + d\Theta + dI + dK + d\Lambda + dM + \\
& dN + d\Xi + dO + d\Pi + dP + d\Sigma + dT + d\Upsilon + d\Phi + dX + d\Psi + d\Omega + \\
& d\alpha + d\beta + d\gamma + d\delta + d\epsilon + d\zeta + d\eta + d\theta + d\iota + d\kappa + d\lambda + d\mu + \\
& dv + d\zeta + do + d\pi + d\rho + d\sigma + d\tau + dv + d\phi + d\chi + d\psi + d\omega + \\
& d\epsilon + d\vartheta + d\varpi + d\varrho + d\varsigma + d\phi + d\ell + d\wp + \\
& dA + dB + d\Gamma + d\Delta + dE + dZ + dH + d\Theta + dI + dK + d\Lambda + dM + \\
& dN + d\Xi + dO + d\Pi + dP + d\Sigma + dT + d\Upsilon + d\Phi + dX + d\Psi + d\Omega +
\end{aligned}$$

$$\begin{aligned}
& dA + dB + dC + dD + dE + dF + dG + dH + dI + dJ + dK + dL + dM + \\
& dN + dO + dP + dQ + dR + dS + dT + dU + dV + dW + dX + dY + dZ + \\
& da + db + dc + dd + de + df + dg + dh + di + dj + dk + dl + dm + \\
& dn + do + dp + dq + dr + ds + dt + du + dv + dw + dx + dy + dz + di + dj + \\
& dA + dB + d\Gamma + d\Delta + dE + dZ + dH + d\Theta + dI + dK + d\Lambda + dM + \\
& dN + d\Xi + dO + d\Pi + dP + d\Sigma + dT + d\Upsilon + d\Phi + dX + d\Psi + d\Omega + \\
& d\alpha + d\beta + d\gamma + d\delta + d\epsilon + d\zeta + d\eta + d\theta + d\iota + d\kappa + d\lambda + d\mu + \\
& dv + d\zeta + do + d\pi + d\rho + d\sigma + d\tau + dv + d\phi + d\chi + d\psi + d\omega + \\
& d\epsilon + d\vartheta + d\varpi + d\varrho + d\varsigma + d\phi + d\ell + d\wp + \\
& dA + dB + d\Gamma + d\Delta + dE + dZ + dH + d\Theta + dI + dK + d\Lambda + dM + \\
& dN + d\Xi + dO + d\Pi + dP + d\Sigma + dT + d\Upsilon + d\Phi + dX + d\Psi + d\Omega +
\end{aligned}$$

$$\begin{aligned}
& \partial A + \partial B + \partial C + \partial D + \partial E + \partial F + \partial G + \partial H + \partial I + \partial J + \partial K + \partial L + \partial M + \\
& \partial N + \partial O + \partial P + \partial Q + \partial R + \partial S + \partial T + \partial U + \partial V + \partial W + \partial X + \partial Y + \partial Z + \\
& \partial a + \partial b + \partial c + \partial d + \partial e + \partial f + \partial g + \partial h + \partial i + \partial j + \partial k + \partial l + \partial m + \\
& \partial n + \partial o + \partial p + \partial q + \partial r + \partial s + \partial t + \partial u + \partial v + \partial w + \partial x + \partial y + \partial z + \partial i + \partial j + \\
& \partial A + \partial B + \partial \Gamma + \partial \Delta + \partial E + \partial Z + \partial H + \partial \Theta + \partial I + \partial K + \partial \Lambda + \partial M + \\
& \partial N + \partial \Xi + \partial O + \partial \Pi + \partial P + \partial \Sigma + \partial T + \partial \Upsilon + \partial \Phi + \partial X + \partial \Psi + \partial \Omega + \\
& \partial \alpha + \partial \beta + \partial \gamma + \partial \delta + \partial \epsilon + \partial \zeta + \partial \eta + \partial \theta + \partial \iota + \partial \kappa + \partial \lambda + \partial \mu + \\
& \partial v + \partial \zeta + \partial o + \partial \pi + \partial \rho + \partial \sigma + \partial \tau + \partial v + \partial \phi + \partial \chi + \partial \psi + \partial \omega + \\
& \partial \epsilon + \partial \vartheta + \partial \varpi + \partial \varrho + \partial \varsigma + \partial \phi + \partial \ell + \partial \wp + \\
& \partial A + \partial B + \partial \Gamma + \partial \Delta + \partial E + \partial Z + \partial H + \partial \Theta + \partial I + \partial K + \partial \Lambda + \partial M + \\
& \partial N + \partial \Xi + \partial O + \partial \Pi + \partial P + \partial \Sigma + \partial T + \partial \Upsilon + \partial \Phi + \partial X + \partial \Psi + \partial \Omega +
\end{aligned}$$

## 2.7 Slash kerning

1/A+1/B+1/C+1/D+1/E+1/F+1/G+1/H+1/I+1/J+1/K+1/L+1/M+  
1/N+1/O+1/P+1/Q+1/R+1/S+1/T+1/U+1/V+1/W+1/X+1/Y+1/Z+  
1/a+1/b+1/c+1/d+1/e+1/f+1/g+1/h+1/i+1/j+1/k+1/l+1/m+  
1/n+1/o+1/p+1/q+1/r+1/s+1/t+1/u+1/v +1/w+1/x+1/y+1/z+1/ι+1/ϵ+  
1/A+1/B+1/Γ+1/Δ+1/E+1/Z+1/H+1/Θ+1/I+1/K+1/Λ+1/M+  
1/N+1/Ξ+1/O+1/Π+1/P+1/Σ+1/T+1/Υ+1/Φ+1/X+1/Ψ+1/Ω+  
1/α+1/β+1/γ+1/δ+1/ε+1/ζ+1/η+1/θ+1/ι+1/κ+1/λ+1/μ+  
1/ν+1/ξ+1/ο+1/π+1/ρ+1/σ+1/τ+1/υ+1/φ+1/χ+1/ψ+1/ω+  
1/ε+1/ϑ+1/Ϙ+1/ϙ+1/ς+1/φ+1/ℓ+1/ϝ+

A/2+B/2+C/2+D/2+E/2+F/2+G/2+H/2+I/2+J/2+K/2+L/2+M/2+  
N/2+O/2+P/2+Q/2+R/2+S/2+T/2+U/2+V/2+W/2+X/2+Y/2+Z/2+  
a/2+b/2+c/2+d/2+e/2+f/2+g/2+h/2+i/2+j/2+k/2+l/2+m/2+  
n/2+o/2+p/2+q/2+r/2+s/2+t/2+u/2+v/2+w/2+x/2+y/2+z/2+ι/2+ϵ/2+  
A/2+B/2+Γ/2+Δ/2+E/2+Z/2+H/2+Θ/2+I/2+K/2+Λ/2+M/2+  
N/2+Ξ/2+O/2+Π/2+P/2+Σ/2+T/2+Υ/2+Φ/2+X/2+Ψ/2+Ω/2+  
α/2+β/2+γ/2+δ/2+ε/2+ζ/2+η/2+θ/2+ι/2+κ/2+λ/2+μ/2+  
ν/2+ξ/2+ο/2+π/2+ρ/2+σ/2+τ/2+υ/2+φ/2+χ/2+ψ/2+ω/2+  
ε/2+ϑ/2+Ϙ/2+ϙ/2+ς/2+φ/2+ℓ/2+ϝ/2+



## 2.8 Big operators

$$\sum_{i=1}^n x^n \quad \prod_{i=1}^n x^n \quad \coprod_{i=1}^n x^n \quad \int_{i=1}^n x^n \quad \oint_{i=1}^n x^n$$

$$\bigotimes_{i=1}^n x^n \quad \bigoplus_{i=1}^n x^n \quad \bigodot_{i=1}^n x^n \quad \bigwedge_{i=1}^n x^n \quad \bigvee_{i=1}^n x^n \quad \biguplus_{i=1}^n x^n \quad \bigcup_{i=1}^n x^n \quad \bigcap_{i=1}^n x^n \quad \bigsqcup_{i=1}^n x^n$$

## 2.9 Radicals

$$\sqrt{x+y} \quad \sqrt{x^2+y^2} \quad \sqrt{x_i^2+y_j^2} \quad \sqrt{\left(\frac{\cos x}{2}\right)} \quad \sqrt{\left(\frac{\sin x}{2}\right)}$$

$$\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{\sqrt{x+y}}}}}}}}}$$

## 2.10 Over- and underbraces

$$\underbrace{x} \quad \underbrace{x+y} \quad \underbrace{x^2+y^2} \quad \underbrace{x_i^2+y_j^2} \quad \underbrace{x} \quad \underbrace{x+y} \quad \underbrace{x_i+y_j} \quad \underbrace{x_i^2+y_j^2}$$

## 2.11 Normal and wide accents

$$\dot{x} \quad \ddot{x} \quad \vec{x} \quad \bar{x} \quad \overline{x} \quad \overline{\overline{x}} \quad \tilde{x} \quad \widetilde{x} \quad \widetilde{\widetilde{x}} \quad \widetilde{\widetilde{\widetilde{x}}} \quad \hat{x} \quad \widehat{x} \quad \widehat{\widehat{x}} \quad \widehat{\widehat{\widehat{x}}}$$

## 2.12 Long arrows

$$\longleftrightarrow \quad \leftrightarrow \quad \longleftarrow \quad \longrightarrow \quad \longleftrightarrow \quad \Longleftrightarrow \quad \Leftrightarrow \quad \Leftarrow \quad \Rightarrow \quad \Longleftrightarrow$$

## 2.13 Left and right delimiters

$$-(f) \; - \; -[f] \; - \; -[f] \; - \; -[f] \; - \; -\langle f \rangle \; - \; -\{f\} \; -$$

$$-(f) \; - \; -[f] \; - \; -[f] \; - \; -[f] \; - \; -\langle f \rangle \; - \; -\{f\} \; -$$

$$-)\mathcal{f}(\; - \; -\mathcal{f}[\; - \; -/f/\; - \; -\mathcal{f}\backslash \; - \; -/f\backslash \; - \; -\mathcal{f}/ \; -$$

## 2.14 Big-g-g delimiters

[illegible]

## 2.15 Symbols

This is from [2]

Symbol	Control Sequence	mathcode	Family	Hex Position
$\partial$	partial	"0140	1	40
$\flat$	flat	"015B	1	5B
$\natural$	natural	"015C	1	5C
$\sharp$	sharp	"015D	1	5D
$\ell$	ell	"0160	1	60
$\imath$	imath	"017B	1	7B
$\jmath$	jmath	"017C	1	7C
$\wp$	wp	"017D	1	7D
$\prime$	prime	"0230	2	30
$\infty$	infty	"0231	2	31
$\triangle$	triangle	"0234	2	34
$\forall$	forall	"0238	2	38
$\exists$	exists	"0239	2	39
$\neg$	neg	"023A	2	3A
$\emptyset$	emptyset	"023B	2	3B
$\Re$	Re	"023C	2	3C
$\Im$	Im	"023D	2	3D

$\top$	top	"023E	2	3E
$\perp$	bot	"023F	2	3F
$\aleph$	aleph	"0240	2	40
$\nabla$	nabla	"0272	2	72
$\clubsuit$	clubsuit	"027C	2	7C
$\diamond$	diamondsuit	"027D	2	7D
$\heartsuit$	heartsuit	"027E	2	7E
$\spadesuit$	spadesuit	"027F	2	7F
$\int \int$	smallint	"1273	2	73
$\sqcup \sqcup$	bigscup	"1346	3	46
$\oint$	ointop	"1348	3	48
$\odot \odot$	bigodot	"134A	3	4A
$\oplus \oplus$	bigoplus	"134C	3	4C
$\otimes \otimes$	bigotimes	"134E	3	4E
$\Sigma \Sigma$	sum	"1350	3	50
$\prod \prod$	prod	"1351	3	51
$\int \int$	intop	"1352	3	52
$\cup \cup$	bigcup	"1353	3	53
$\cap \cap$	bigcap	"1354	3	54
$\uplus \uplus$	biguplus	"1355	3	55
$\wedge \wedge$	bigwedge	"1356	3	56
$\vee \vee$	bigvee	"1357	3	57
$\amalg \amalg$	coprod	"1360	3	60
$\triangleright$	triangleright	"212E	1	2E
$\triangleleft$	triangleleft	"212F	1	2F
$\star$	star	"213F	1	3F
$\cdot$	cdot	"2201	2	01
$\times$	times	"2202	2	02
$*$	ast	"2203	2	03
$\div$	div	"2204	2	04
$\diamond$	diamond	"2205	2	05
$\pm$	pm	"2206	2	06
$\mp$	mp	"2207	2	07
$\oplus$	oplus	"2208	2	08
$\ominus$	ominus	"2209	2	09
$\otimes$	otimes	"220A	2	0A
$\oslash$	oslash	"220B	2	0B
$\odot$	odot	"220C	2	0C
$\bigcirc$	bigcirc	"220D	2	0D
$\circ$	circ	"220E	2	0E

•	bullet	"220F	2	0F
△	bigtriangleup	"2234	2	34
▽	bigtriangledown	"2235	2	35
∪	cup	"225B	2	5B
∩	cap	"225C	2	5C
⊕	uplus	"225D	2	5D
∧	wedge	"225E	2	5E
∨	vee	"225F	2	5F
∖	setminus	"226E	2	6E
ℳ	wr	"226F	2	6F
⧿	amalg	"2271	2	71
⊔	sqcup	"2274	2	74
⊓	sqcap	"2275	2	75
⋈	dagger	"2279	2	79
⋉	ddagger	"227A	2	7A
↰	leftharpoonup	"3128	1	28
↱	leftharpoondown	"3129	1	29
↶	rightharpoonup	"312A	1	2A
↷	rightharpoondown	"312B	1	2B
☺	smile	"315E	1	5E
☹	frown	"315F	1	5F
∞	asymp	"3210	2	10
≡	equiv	"3211	2	11
⊂	subseteq	"3212	2	12
⊃	supseteq	"3213	2	13
≤	leq	"3214	2	14
≥	geq	"3215	2	15
⊆	preceq	"3216	2	16
⊇	succeq	"3217	2	17
≈	sim	"3218	2	18
≈	approx	"3219	2	19
⊂	subset	"321A	2	1A
⊃	supset	"321B	2	1B
⋈	ll	"321C	2	1C
⋉	gg	"321D	2	1D
⋈	prec	"321E	2	1E
⋉	succ	"321F	2	1F
←	leftarrow	"3220	2	20
→	rightarrow	"3221	2	21
↔	leftrightharrow	"3224	2	24
↗	nearrow	"3225	2	25
↘	searrow	"3226	2	26
⋈	simeq	"3227	2	27
⇐	Leftarrow	"3228	2	28
⇒	Rightarrow	"3229	2	29
⇔	Leftrightarrow	"322C	2	2C

$\nwarrow$	narrow	"322D	2	2D
$\swarrow$	swarrow	"322E	2	2E
$\propto$	propto	"322F	2	2F
$\in$	in	"3232	2	32
$\ni$	ni	"3233	2	33
$/$	not	"3236	2	36
$\mapsto$	mapsto	"3237	2	37
$\perp$	perp	"323F	2	3F
$\vdash$	vdash	"3260	2	60
$\dashv$	dashv	"3261	2	61
$ $	mid	"326A	2	6A
$\parallel$	parallel	"326B	2	6B
$\sqsubseteq$	squasubseteq	"3276	2	76
$\sqsupseteq$	squasupseteq	"3277	2	77

## 2.16 Miscellaneous formulae

Taken from [3]

$$\hbar\nu = E$$

Let  $\mathbf{A} = (a_{ij})$  be the adjacency matrix of graph  $G$ . The corresponding Kirchhoff matrix  $\mathbf{K} = (k_{ij})$  is obtained from  $\mathbf{A}$  by replacing in  $-\mathbf{A}$  each diagonal entry by the degree of its corresponding vertex; i.e., the  $i$ th diagonal entry is identified with the degree of the  $i$ th vertex. It is well known that

$$\det \mathbf{K}(i|i) = \text{the number of spanning trees of } G, \quad i = 1, \dots, n \quad (5)$$

where  $\mathbf{K}(i|i)$  is the  $i$ th principal submatrix of  $\mathbf{K}$ .

Let  $C_{i(j)}$  be the set of graphs obtained from  $G$  by attaching edge  $(v_i v_j)$  to each spanning tree of  $G$ . Denote by  $C_i = \bigcup_j C_{i(j)}$ . It is obvious that the collection of Hamiltonian cycles is a subset of  $C_i$ . Note that the cardinality of  $C_i$  is  $k_{ii} \det \mathbf{K}(i|i)$ . Let  $\hat{X} = \{\hat{x}_1, \dots, \hat{x}_n\}$ . Define multiplication for the elements of  $\hat{X}$  by

$$\hat{x}_i \hat{x}_j = \hat{x}_j \hat{x}_i, \quad \hat{x}_i^2 = 0, \quad i, j = 1, \dots, n. \quad (6)$$

Let  $\hat{k}_{ij} = k_{ij} \hat{x}_j$  and  $\hat{k}_{ij} = -\sum_{j \neq i} \hat{k}_{ij}$ . Then the number of Hamiltonian cycles  $H_c$  is given by the relation

$$\left( \prod_{j=1}^n \hat{x}_j \right) H_c = \frac{1}{2} \hat{k}_{ij} \det \hat{\mathbf{K}}(i|i), \quad i = 1, \dots, n. \quad (7)$$

The task here is to express (7) in a form free of any  $\hat{x}_i$ ,  $i = 1, \dots, n$ . The result also leads to the resolution of enumeration of Hamiltonian paths in a graph. It is well known that the enumeration of Hamiltonian cycles and paths in a complete graph  $K_n$  and in a complete bipartite graph  $K_{n_1 n_2}$  can only be found from *first combinatorial principles*. One wonders if there exists a formula which can

be used very efficiently to produce  $K_n$  and  $K_{n_1 n_2}$ . Recently, using Lagrangian methods, Goulden and Jackson have shown that  $H_c$  can be expressed in terms of the determinant and permanent of the adjacency matrix. However, the formula of Goulden and Jackson determines neither  $K_n$  nor  $K_{n_1 n_2}$  effectively. In this paper, using an algebraic method, we parametrize the adjacency matrix. The resulting formula also involves the determinant and permanent, but it can easily be applied to  $K_n$  and  $K_{n_1 n_2}$ . In addition, we eliminate the permanent from  $H_c$  and show that  $H_c$  can be represented by a determinantal function of multivariables, each variable with domain  $\{0, 1\}$ . Furthermore, we show that  $H_c$  can be written by number of spanning trees of subgraphs. Finally, we apply the formulas to a complete multigraph  $K_{n_1 \dots n_p}$ .

The conditions  $a_{ij} = a_{ji}$ ,  $i, j = 1, \dots, n$ , are not required in this paper. All formulas can be extended to a digraph simply by multiplying  $H_c$  by 2.

The boundedness, property of  $\Phi_0$ , then yields

$$\int_{\mathcal{D}} |\bar{\partial} u|^2 e^{\alpha|z|^2} \geq c_6 \alpha \int_{\mathcal{D}} |u|^2 e^{\alpha|z|^2} + c_7 \delta^{-2} \int_A |u|^2 e^{\alpha|z|^2}.$$

Let  $B(X)$  be the set of blocks of  $\Lambda_X$  and let  $b(X) = |B(X)|$ . If  $\phi \in Q_X$  then  $\phi$  is constant on the blocks of  $\Lambda_X$ .

$$P_X = \{\phi \in M \mid \Lambda_\phi = \Lambda_X\}, \quad Q_X = \{\phi \in M \mid \Lambda_\phi \geq \Lambda_X\}. \quad (8)$$

If  $\Lambda_\phi \geq \Lambda_X$  then  $\Lambda_\phi = \Lambda_Y$  for some  $Y \geq X$  so that

$$Q_X = \bigcup_{Y \geq X} P_Y.$$

Thus by Möbius inversion

$$|P_Y| = \sum_{X \geq Y} \mu(Y, X) |Q_X|.$$

Thus there is a bijection from  $Q_X$  to  $W^{B(X)}$ . In particular  $|Q_X| = w^{b(X)}$ .

$$W(\Phi) = \left\| \begin{array}{ccccc} \frac{\varphi}{(\varphi_1, \varepsilon_1)} & 0 & \cdots & 0 \\ \frac{\varphi k_{n2}}{(\varphi_2, \varepsilon_1)} & \frac{\varphi}{(\varphi_2, \varepsilon_2)} & \cdots & 0 \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ \frac{\varphi k_{n1}}{(\varphi_n, \varepsilon_1)} & \frac{\varphi k_{n2}}{(\varphi_n, \varepsilon_2)} & \cdots & \frac{\varphi k_{nn-1}}{(\varphi_n, \varepsilon_{n-1})} & \frac{\varphi}{(\varphi_n, \varepsilon_n)} \end{array} \right\|$$

## References

- [1] Walter Schmidt. *Using Common PostScript Fonts With L<sup>A</sup>T<sub>E</sub>X. PSNFSS Version 9.2*, September 2004. <http://ctan.tug.org/tex-archive/macros/latex/required/psnfss>.

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