

# Fourier Coefficients of a Class of Eta Quotients of Weight 4

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## Abstract

Recently, there have been several works on the coefficients of the Fourier series expansions of a class of eta quotients by Williams, Yao, Xia and Jin, Kendirli, and Alaca. Some important explicit formulas have been discovered. Williams expressed all coefficients of one hundred and twenty-six eta quotients in terms of  $\sigma(n), \sigma(\frac{n}{2}), \sigma(\frac{n}{3})$  and  $\sigma(\frac{n}{6})$ , and Yao, Xia and Jin, following the method of proof of Williams, expressed only even coefficients of one hundred and four eta quotients in terms of  $\sigma_3(n), \sigma_3(\frac{n}{2}), \sigma_3(\frac{n}{3})$  and  $\sigma_3(\frac{n}{6})$ . The author has expressed the even and odd coefficients of the Fourier series expansions of a class of eta quotients in terms of  $\sigma_{k-1}(n), \sigma_{k-1}(\frac{n}{2}), \sigma_{k-1}(\frac{n}{3})$  and  $\sigma_{k-1}(\frac{n}{6})$  for  $k = 6, 8, 10, 12, 14, 16, 18, 20, 22, 24$ . Meanwhile, Alaca has obtained the coefficients of the Fourier series expansions of a class of eta quotients in  $M_2(\Gamma_0, \chi)$  in terms of  $\sigma(n), \sigma(\frac{n}{2}), \sigma(\frac{n}{3})$  and  $\sigma(\frac{n}{6})$ . Here, we will express the coefficients of the Fourier series expansions of a class of eta quotients in  $M_4(\Gamma_0, \chi)$  in terms of  $\sigma_3(n), \sigma_3(\frac{n}{2}), \sigma_3(\frac{n}{3}), \sigma_3(\frac{n}{6})$  and Fourier coefficients of the four eta quotients.

**Keywords:** Dedekind eta function; Eisenstein series; Eta quotients; Fourier coefficients; Modular forms.

## 1. Introduction

The divisor function  $\sigma_i(n)$  is defined for a positive integer  $i$  by

$$\sigma_i(n) := \sum_{d \mid n} d^i, \text{ if } n \text{ is a positive integer, and}$$

$$\sigma_i(n) := 0, \text{ if } n \text{ is not a positive integer.}$$

The Dedekind eta function is defined by

$$\eta(z) := q^{1/24} \prod_{n=1}^{\infty} (1 - q^n),$$

where

$$q := e^{2\pi iz}, z \in \mathbb{H} = \{x + iy : y > 0\}$$

and, an eta quotient of level  $n$  is defined by

$$f(z) := \prod_{m \mid n} \eta(mz)^{a_m}, n, m \in \mathbb{N}, a_m \in \mathbb{Z}.$$

There have been considerable effort to determine explicit formulas for the Fourier coefficients of eta quotients since they are the building blocks of modular forms of level  $n$  and weight  $k$ . The book of Köhler [1] (Chapter 3, pg.39) describes such expansions by means of Hecke Theta series, and it develops algorithms for the determination of suitable eta quotients. One can find more information in [2], [3], [4], [5] and [6]. The author has also determined the Fourier coefficients of the theta series associated with some quadratic forms, see [8], [9], [10], [11], [12] and [13]. Recently, Williams [14] discovered explicit formulas for the coefficients of Fourier series expansions of a class of one hundred and twenty-six eta quotients in terms of  $\sigma(n), \sigma(\frac{n}{2}), \sigma(\frac{n}{3})$  and  $\sigma(\frac{n}{6})$ . One example is as follows:

$$\frac{\eta^2(2z)\eta^4(4z)\eta^6(6z)}{\eta^2(z)\eta^2(3z)\eta^4(12z)} = 1 + \sum_{n=1}^{\infty} c(n)q^n,$$

where

$$c(n) = 2\sigma(n) - 3\sigma(n/2) + 4\sigma(n/4) + 9\sigma(n/6) - 36\sigma(n/12).$$

Then Yao, Xia and Jin [15] expressed the even Fourier coefficients of one hundred and four eta quotients in terms of  $\sigma_3(n), \sigma_3(\frac{n}{2}), \sigma_3(\frac{n}{3})$  and  $\sigma_3(\frac{n}{6})$ . One example is as follows:

$$\frac{\eta^{25}(2z)\eta^4(3z)}{\eta^{12}(z)\eta^5(4z)\eta^3(6z)\eta(12z)} = 1 + \sum_{n=1}^{\infty} c(n)q^n,$$

where

$$c(2n) = 65\sigma_3(n) - 68\sigma_3(n/2) - 81\sigma_3(n/3) + 324\sigma_3(n/6).$$

Motivated by these two results, we find that we can express the even and odd coefficients of the Fourier series expansions of a class of eta quotients in terms of  $\sigma_{k-1}(n), \sigma_{k-1}(\frac{n}{2}), \sigma_{k-1}(\frac{n}{3})$  and  $\sigma_{k-1}(\frac{n}{6})$  for  $k = 6[16], 8[17], 10[18], 12[19], 14[20], 16[21], 18[22], 20[23], 22[24], 24[25]$ . Meanwhile, Alaca [26] has obtained the coefficients of the Fourier series expansions of a class of eta quotients in  $M_2(\Gamma_0, \chi)$  in terms of  $\sigma(n), \sigma(\frac{n}{2}), \sigma(\frac{n}{3})$  and  $\sigma(\frac{n}{6})$ . Here, we will express the coefficients of the Fourier series expansions of a class of one hundred and fifty-six eta quotients in  $M_4(\Gamma_0, \chi)$  in terms of  $\sigma_3(n), \sigma_3(\frac{n}{2}), \sigma_3(\frac{n}{3}), \sigma_3(\frac{n}{6})$  and the Fourier coefficients of the four eta quotients.

Here we give the following Lemma, see [27] Theorem 1.64] about the modularity of an eta quotient.

Lemma 1. An eta quotient of level N is a meromorphic modular form of weight  $\frac{1}{2} \sum_{m|N} a_m$  on  $\Gamma_0(N)$ , with Dirichlet character  $\chi$ , having rational coefficients with respect to q if

a)  $\sum_{m|N} a_m$  is even,

b)  $\sum_{m|N} m a_m \equiv \sum_{m|N} \frac{N}{m} a_m \equiv 0 \pmod{24}$ ,

c)  $\chi(m) = \left( \frac{(-1)^k \prod_{m|N} m^{a_m}}{m} \right)$ .

In particular, since

$$2^{a_2} 3^{a_3} 4^{a_4} 6^{a_6} 12^{a_{12}} = 2^{a_2+2a_4+a_6+2a_{12}} 3^{a_3+a_6+a_{12}},$$

an eta quotient of level 12 is a meromorphic modular form of weight 4 if

$$a_1 + a_2 + a_3 + a_4 + a_6 + a_{12} = 8$$

and

$$a_1 + 2a_2 + 3a_3 + 4a_4 + 6a_6 + 12a_{12} \equiv 12a_1 + 6a_2 + 4a_3 + 3a_4 + 2a_6 + a_{12} \equiv 0 \pmod{24}.$$

Since  $a_2 + a_6$  is an even integer, we conclude that it is a meromorphic modular form iff  $a_3 + a_6 + a_{12}$  is an even integer, and it is a meromorphic modular form with  $\chi_3$  iff  $a_3 + a_6 + a_{12}$  is an odd integer, where  $\chi_3$  is the unique primitive Dirichlet character mod 12. On the other hand, the modular forms are holomorphic iff its order at cusps,  $\frac{1}{1}, \frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \frac{1}{6}$  and  $\frac{1}{12}$  are nonnegative, see [1] i.e.,

$$\sum_{m|12} \frac{(\gcd(c,m))^2}{m} a_m \geq 0 \text{ for } c|12.$$

**Theorem 1:** Let  $\chi_0$  be the trivial character mod 1, i.e., it sends n to 1,  $\chi_1$  be the primitive Dirichlet character mod 4, and  $\chi_2$  is the primitive Dirichlet character mod 3. Then the Eisenstein subspace of  $M_4(\Gamma_0(12), \chi_3)$  is generated by

$$E_4^{X_1 X_2} = \sum_{n=1}^{\infty} (\sum_{0 < d|n} \chi_1 \left( \frac{n}{d} \right) \chi_2(d) d^3) q^n = q - q^2 + 41q^3 + 113q^4 - 124q^5 + 155q^6 + 874q^7 + O(q^8),$$

$$E_4^{X_2 X_1} = \sum_{n=1}^{\infty} (\sum_{0 < d|n} \chi_2 \left( \frac{n}{d} \right) \chi_1(d) d^3) q^n = q - q^2 - 27q^3 + q^4 + 124q^5 + 27q^6 - 342q^7 + O(q^8),$$

$$E_4^{X_0 X_3} = -\frac{B_4 \chi_3}{8} + \sum_{n=1}^{\infty} (\sum_{0 < d|n} \chi_0 \left( \frac{n}{d} \right) \chi_3(d) d^3) q^n = 23 + q + q^2 + q^3 + q^4 - 124q^5 + q^6 - 342q^7 + O(q^8),$$

$$E_4^{X_3 X_0} = \sum_{n=1}^{\infty} (\sum_{0 < d|n} \chi_3 \left( \frac{n}{d} \right) \chi_0(d) d^3) q^n = q + 8q^2 + 27q^3 + 64q^4 + 124q^5 + 216q^6 + 342q^7 + O(q^8)$$

and, the cuspidal subspace  $S_4(\Gamma_0(12), \chi_3)$  is generated by

$$f_1 := \sum_{n=0}^{\infty} f_1(n) q^n = \frac{\eta^2(2z) \eta^{10}(3z) \eta(4z) \eta(12z)}{\eta^2(z) \eta^4(6z)},$$

$$f_2 := \sum_{n=0}^{\infty} f_2(n) q^n = \frac{\eta^2(2z) \eta^7(3z) \eta^4(12z)}{\eta(z) \eta^4(6z)},$$

$$f_3 := \sum_{n=0}^{\infty} f_3(n) q^n = \frac{\eta^4(z) \eta^7(4z) \eta^2(6z)}{\eta^4(2z) \eta(12z)},$$

$$f_4 := \sum_{n=0}^{\infty} f_4(n) q^n = \frac{\eta^4(z) \eta^2(4z) \eta^7(6z)}{\eta^3(2z) \eta^2(12z)}.$$

Proof:  
Since

$$\chi_3 = \chi_0 * \chi_3, \chi_3 = \chi_3 * \chi_0, \chi_3 = \chi_1 * \chi_2, \chi_3 = \chi_2 * \chi_1,$$

the Eisenstein subspace of  $M_4(\Gamma_0(12), \chi_3)$  is generated by  $E_4^{X_1 X_2}, E_4^{X_2 X_1}, E_4^{X_0 X_3}$  and  $E_4^{X_3 X_0}$ . Since  $f_1, f_2, f_3$  and  $f_4$  are in  $S_4(\Gamma_0(12), \chi_3)$ , linearly independent and  $\dim(S_4(\Gamma_0(12), \chi_3)) = 4$ , the result follows. Let

$$\delta(b_1) = \begin{cases} 0 & \text{if } b_1 \neq 0 \\ 1 & \text{if } b_1 = 0 \end{cases}$$

Now we can state our main Conclusion:

**Theorem 2:** The coefficients of the Fourier series of one hundred and fifty-six eta quotients

$$\eta^{a_1}(z) \eta^{a_2}(2z) \eta^{a_3}(3z) \eta^{a_4}(4z) \eta^{a_6}(6z) \eta^{a_{12}}(12z) = \delta(b_1) + \sum_{n=1}^{\infty} c(n) q^n$$

in  $M_4(\Gamma_0(12), \chi_3)$  are given in the form

$$c_1 \sigma_3(n) + c_2 \sigma_3 \left( \frac{n}{2} \right) + c_3 \sigma_3 \left( \frac{n}{3} \right) + c_4 \sigma_3 \left( \frac{n}{4} \right) + c_6 \sigma_3 \left( \frac{n}{6} \right) + c_{12} \sigma_3 \left( \frac{n}{12} \right) + r_1 f_1(n) + r_2 f_2(n) + r_3 f_3(n) + r_4 f_4(n)$$

As in the Table in Appendix.

**Remark 1:** The coefficients of the Fourier series of the 104 eta quotients in  $M_4(\Gamma_0(12))$  are given in the form

$$c_1 \sigma_3(n) + c_2 \sigma_3 \left( \frac{n}{2} \right) + c_3 \sigma_3 \left( \frac{n}{3} \right) + c_4 \sigma_3 \left( \frac{n}{4} \right) + c_6 \sigma_3 \left( \frac{n}{6} \right) + c_{12} \sigma_3 \left( \frac{n}{12} \right)$$

$$+ r_1 g_1(n) + r_2 g_2(n) + r_3 h(n), g_1(2n) = g_2(2n) = h(2n - 1) = 0,$$

exactly as in [15]. But our method is obviously much simpler than it since we didn't need to use (p, k) parametrizations.

**Remark 2:**  $S_4(\Gamma_0(12), \chi_3)$  is 4 dimensional, see [28] (Chapter 3, pg.87 and Chapter 5, pg.197), and it is generated by  $\Delta_s$ , and its three conjugates, where  $t = \sqrt{3}, s = \sqrt{-140 + 80\sqrt{3}}$  and

$$\Delta_s = q + \frac{1}{160}(-s^3 + 2s^2 - 300s + 280)q^2 + \frac{1}{80}(s^3 - 2s^2 + 260s - 280)q^3 + \frac{1}{40}(-s^3 - 260s - 80)q^4 + \frac{1}{40}(s^3 + 300s)q^5 + \frac{1}{160}(7s^3 + 10s^2 + 1940s + 440)q^6 + \frac{1}{40}(-s^3 - 260s)q^7 + \frac{1}{40}(-s^3 - 6s^2 - 300s - 840)q^8 + \frac{1}{40}(-3s^3 - 900s - 120)q^9 + \frac{1}{20}(s^3 + 260s + 400)q^{10} + \frac{1}{4}(s^2 + 140)q^{11} + O(q^{12}).$$

Here,  $s, -s, (4 * t + 7) * s$  and  $-(4 * t + 7) * s$  are distinct four conjugate roots of the irreducible polynomial  $x^4 + 280x^2 + 400$ . By simple calculation, we see that

$$f_1 = \left( \frac{1}{120}(7t + 15)s + \frac{1}{12}(-t + 3) \right) \Delta_s(z) + \left( \frac{1}{120}(-7t - 15)s + \frac{1}{12}(-t + 3) \right) \Delta_{-s}(z) + \left( \frac{1}{120}(11t + 21)s + \frac{1}{12}(t + 3) \right) \Delta_{(4*t+7)*s}(z) + \left( \frac{1}{120}(-11t - 21)s + \frac{1}{12}(t + 3) \right) \Delta_{-(4*t+7)*s}(z),$$

$$f_2 = \left( \frac{1}{80}(3t + 6)s - \frac{1}{24}t \right) \Delta_s(z) + \left( \frac{1}{80}(-3t - 6)s - \frac{1}{24}t \right) \Delta_{-s}(z) + \left( \frac{1}{80}(3t + 6)s + \frac{1}{24}t \right) \Delta_{(4*t+7)*s}(z) + \left( \frac{1}{80}(-3t - 6)s + \frac{1}{24}t \right) \Delta_{-(4*t+7)*s}(z),$$

$$f_3 = \left( \frac{1}{80}(-9t - 16)s + \frac{1}{8}(-t + 2) \right) \Delta_s(z) + \left( \frac{1}{80}(9t + 16)s + \frac{1}{8}(-t + 2) \right) \Delta_{-s}(z) + \left( \frac{1}{80}(-t - 4)s + \frac{1}{8}(t + 2) \right) \Delta_{(4*t+7)*s}(z) + \left( \frac{1}{80}(t + 4)s + \frac{1}{8}(t + 2) \right) \Delta_{-(4*t+7)*s}(z),$$

$$f_4 = \left( \frac{1}{120}(-8t - 15)s + \frac{1}{12}(-2t + 3) \right) \Delta_s(z) + \left( \frac{1}{120}(8t + 15)s + \frac{1}{12}(-2t + 3) \right) \Delta_{-s}(z) + \left( \frac{1}{120}(-4t - 9)s + \frac{1}{12}(2t + 3) \right) \Delta_{(4*t+7)*s}(z) + \left( \frac{1}{120}(4t + 9)s + \frac{1}{12}(2t + 3) \right) \Delta_{-(4*t+7)*s}(z).$$

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Appendix

Table

No	$a_1$	$a_2$	$a_3$	$a_4$	$a_6$	$a_{12}$	$c_1$	$c_2$	$c_3$	$c_4$	$r_1$	$r_2$	$r_3$	$r_4$
1	-10	20	10	-9	-10	7	$\frac{16}{23}$	0	0	$-\frac{1}{23}$	0	$-\frac{166}{23}$	$\frac{12}{23}$	$-\frac{27}{23}$
2	-9	16	7	-2	-6	2	$\frac{23}{36}$	0	0	0	$-\frac{109}{205}$	$-\frac{23}{205}$	$-\frac{9}{23}$	$\frac{77}{23}$
3	-9	20	-1	-4	2	0	$\frac{23}{27}$	0	$\frac{1}{23}$	0	$-\frac{21}{184}$	$\frac{42}{92}$	$\frac{16}{23}$	$-\frac{21}{184}$
4	-8	14	4	1	-4	1	$\frac{23}{27}$	0	0	0	$\frac{46}{15}$	$\frac{23}{51}$	$\frac{23}{23}$	$\frac{3}{46}$
5	-8	9	12	2	-5	-2	$\frac{96}{23}$	$\frac{1}{23}$	0	0	$\frac{111}{23}$	$\frac{282}{23}$	$-\frac{40}{23}$	$\frac{16}{23}$
6	-7	10	1	8	0	-4	$\frac{725}{276}$	0	$\frac{9}{92}$	$\frac{7}{69}$	$\frac{3769}{736}$	$-\frac{3371}{368}$	$\frac{23}{92}$	$-\frac{289}{736}$
7	-7	13	9	-7	-9	9	$\frac{8}{69}$	0	0	$-\frac{1}{69}$	$\frac{5}{46}$	-2	$\frac{14}{69}$	$-\frac{19}{46}$
8	-7	17	1	-9	-1	7	$\frac{2}{23}$	0	0	$\frac{1}{23}$	$-\frac{43}{184}$	$\frac{21}{92}$	$-\frac{5}{23}$	$\frac{59}{184}$
9	-7	18	9	-8	-8	4	0	0	0	$\frac{3}{23}$	$-\frac{22}{23}$	$\frac{376}{23}$	$-\frac{48}{23}$	$-\frac{90}{23}$
10	-7	7	9	5	-3	-3	$\frac{72}{64}$	$\frac{1}{23}$	0	0	$\frac{221}{46}$	$-\frac{244}{23}$	$-\frac{34}{23}$	$\frac{1}{2}$
11	-7	8	9	0	2	-4	$\frac{64}{23}$	$\frac{1}{23}$	0	0	$\frac{46}{118}$	$-\frac{23}{216}$	$-\frac{32}{23}$	$\frac{10}{23}$
12	-6	9	6	0	-5	4	$\frac{6}{23}$	0	0	0	$-\frac{113}{368}$	$-\frac{53}{184}$	$-\frac{3}{46}$	$\frac{23}{368}$
13	-6	13	-2	-2	3	2	$\frac{9}{46}$	0	$\frac{1}{7}$	0	$-\frac{368}{66}$	$\frac{167}{184}$	$\frac{9}{46}$	$-\frac{19}{368}$
14	-6	16	6	-5	-6	3	$\frac{390}{29}$	0	$\frac{46}{87}$	$\frac{66}{29}$	$\frac{368}{87}$	$-\frac{13869}{1288}$	$\frac{46}{29}$	$-\frac{109}{29}$
15	-6	20	-2	-7	2	1	$-\frac{806}{29}$	0	$\frac{1}{87}$	$-\frac{32}{29}$	$\frac{2600}{87}$	$\frac{29289}{29}$	$\frac{3009}{29}$	$\frac{117}{29}$
16	-6	6	6	3	4	-5	$\frac{48}{23}$	$\frac{1}{23}$	0	0	$\frac{110}{23}$	$-\frac{206}{23}$	$-\frac{28}{23}$	$\frac{7}{23}$
17	-6	6	14	-3	-8	5	$\frac{64}{207}$	0	0	$-\frac{1}{207}$	$-\frac{5}{23}$	$-\frac{32}{23}$	0	$-\frac{2}{23}$

18	-6	7	6	-2	9	-6	$\frac{128}{69}$	$\frac{1}{23}$	0	$-\frac{1}{69}$	$\frac{120}{23}$	$-\frac{224}{23}$	$-\frac{64}{69}$	$-\frac{4}{23}$
19	-6	7	6	4	-3	0	$\frac{18}{23}$	0	0	0	$\frac{121}{368}$	$-\frac{251}{184}$	$-\frac{9}{46}$	$\frac{31}{368}$
20	-5	7	3	3	-3	3	0	0	0	0	$\frac{1}{2}$	7	0	$\frac{1}{2}$
21	-5	12	3	2	-2	-2	$-\frac{1}{69}$	0	$\frac{2}{23}$	$\frac{7}{69}$	$\frac{1075}{184}$	$-\frac{629}{92}$	$-\frac{9}{23}$	$-\frac{5}{8}$
22	-5	5	3	1	11	-7	$\frac{32}{23}$	$\frac{1}{23}$	0	0	$\frac{102}{23}$	$-\frac{96}{423}$	$-\frac{24}{549}$	$\frac{4}{23}$
23	-5	5	3	7	-1	-1	$\frac{23}{46}$	0	0	0	$\frac{736}{117}$	$-\frac{368}{99}$	$-\frac{92}{3}$	$\frac{23}{736}$
24	-5	6	3	2	4	-2	$\frac{12}{23}$	0	0	0	$\frac{184}{184}$	$-\frac{92}{21}$	$-\frac{23}{4}$	$-\frac{184}{3}$
25	-5	6	11	-4	-8	8	$\frac{16}{207}$	0	0	$-\frac{1}{207}$	0	$-\frac{21}{23}$	$\frac{6}{49}$	$-\frac{23}{171}$
26	-4	3	0	10	1	-2	$\frac{81}{184}$	0	$\frac{1}{184}$	0	$\frac{549}{736}$	$-\frac{639}{84}$	$-\frac{39}{168}$	$\frac{171}{736}$
27	-4	4	0	-1	18	-9	$\frac{64}{69}$	$\frac{1}{23}$	0	$\frac{1}{69}$	$\frac{84}{23}$	$-\frac{168}{151}$	$-\frac{80}{8}$	$\frac{12}{23}$
28	-4	4	0	5	6	-3	$\frac{9}{23}$	0	0	0	$\frac{151}{184}$	$-\frac{149}{5}$	$-\frac{8}{23}$	$\frac{23}{184}$
29	-4	4	8	-1	-6	7	$\frac{4}{69}$	0	0	0	$\frac{92}{92}$	$-\frac{17}{46}$	$-\frac{1}{69}$	$\frac{1}{92}$
30	-4	4	16	-1	-6	-1	0	$\frac{1}{23}$	0	$\frac{1}{69}$	$\frac{104}{23}$	$-\frac{32}{85}$	$-\frac{64}{69}$	$\frac{8}{23}$
31	-4	5	0	0	11	-4	$\frac{8}{23}$	0	0	0	$\frac{23}{92}$	$-\frac{79}{46}$	$-\frac{2}{23}$	$\frac{17}{92}$
32	-4	5	0	6	-1	2	$\frac{27}{184}$	0	$-\frac{1}{184}$	0	$-\frac{63}{368}$	$\frac{45}{184}$	$\frac{7}{46}$	$-\frac{45}{368}$
33	-4	6	8	-5	-8	11	$\frac{4}{207}$	0	0	$-\frac{1}{207}$	$\frac{5}{92}$	$-\frac{25}{46}$	$\frac{5}{69}$	$-\frac{13}{92}$
34	-4	10	0	-7	0	9	$\frac{1}{69}$	0	0	$\frac{1}{69}$	$-\frac{1}{23}$	$\frac{1}{23}$	$\frac{1}{69}$	0
35	-4	10	0	5	0	-3	$-\frac{1}{69}$	0	$\frac{3}{23}$	$\frac{7}{69}$	$\frac{407}{92}$	$-\frac{283}{46}$	$-\frac{15}{23}$	$\frac{1}{92}$
36	-4	11	8	-6	-7	6	0	0	0	$\frac{1}{23}$	$\frac{15}{23}$	$\frac{110}{23}$	$-\frac{16}{23}$	$\frac{30}{23}$
37	-4	15	0	-8	1	4	0	0	0	$-\frac{3}{23}$	$\frac{19}{92}$	$\frac{23}{46}$	$\frac{2}{23}$	$\frac{15}{92}$
38	-3	2	5	2	-4	6	$\frac{1}{23}$	0	0	0	$-\frac{53}{736}$	$-\frac{33}{368}$	$-\frac{1}{92}$	$\frac{29}{736}$
39	-3	3	-3	3	13	-5	$\frac{6}{23}$	0	0	0	$\frac{185}{184}$	$-\frac{199}{92}$	$-\frac{13}{23}$	$\frac{55}{184}$
40	-3	3	5	-3	1	5	$\frac{8}{207}$	0	0	$\frac{1}{207}$	$-\frac{5}{46}$	$\frac{4}{23}$	$-\frac{2}{23}$	$\frac{7}{46}$
41	-3	4	-3	-2	18	-6	$-\frac{16}{69}$	0	0	$\frac{1}{69}$	$\frac{49}{46}$	$-\frac{51}{23}$	$-\frac{23}{69}$	$\frac{1}{46}$
42	-3	4	-3	4	6	0	$\frac{9}{92}$	0	$-\frac{1}{92}$	0	$-\frac{71}{736}$	$\frac{133}{368}$	$\frac{21}{92}$	$-\frac{7}{32}$
43	-3	4	5	-2	-6	10	$\frac{1}{69}$	0	0	0	$\frac{13}{736}$	$-\frac{103}{368}$	$-\frac{1}{276}$	$\frac{21}{736}$
44	-3	4	13	-2	-6	2	0	0	0	$\frac{1}{69}$	$\frac{18}{23}$	$\frac{52}{67}$	$-\frac{16}{69}$	$\frac{10}{23}$
45	-3	6	-3	0	4	4	$\frac{3}{92}$	0	$\frac{1}{92}$	0	$-\frac{65}{736}$	$\frac{23}{368}$	$-\frac{1}{92}$	$\frac{41}{736}$
46	-3	9	5	-3	-5	5	0	0	0	0	$\frac{5}{7}$	$\frac{2}{103}$	0	$\frac{1}{4}$
47	-3	13	-3	-5	3	3	0	0	0	0	$\frac{4}{184}$	$\frac{92}{503}$	$-\frac{1177}{46}$	$\frac{479}{184}$
48	-3	14	5	-4	-4	0	$-\frac{1}{69}$	0	$\frac{2}{23}$	$\frac{7}{69}$	$\frac{184}{92}$	$-\frac{14}{23}$	$-\frac{4}{5}$	$\frac{13}{7}$
49	-2	0	2	5	-2	5	$\frac{3}{92}$	0	0	0	$-\frac{57}{736}$	$\frac{27}{368}$	$\frac{23}{92}$	$-\frac{7}{736}$
50	-2	2	-6	1	20	-7	$\frac{4}{23}$	0	0	0	$\frac{25}{23}$	$-\frac{60}{15}$	$-\frac{24}{3}$	$\frac{18}{9}$
51	-2	2	2	1	-4	9	$\frac{1}{92}$	0	0	0	$\frac{1}{184}$	$-\frac{92}{92}$	$-\frac{3}{46}$	$\frac{9}{184}$
52	-2	2	10	1	-4	1	0	0	0	0	1	0	0	0
53	-2	3	-6	2	13	-2	$\frac{3}{46}$	0	$-\frac{1}{46}$	0	$-\frac{3}{368}$	$\frac{33}{184}$	$\frac{11}{46}$	$-\frac{101}{368}$
54	-2	3	2	-4	1	8	$\frac{2}{207}$	0	0	$\frac{1}{207}$	$-\frac{7}{368}$	$-\frac{3}{184}$	$-\frac{11}{138}$	$\frac{31}{368}$
55	-2	3	2	8	1	-4	0	$\frac{1}{23}$	0	0	$\frac{801}{368}$	$-\frac{603}{184}$	$-\frac{9}{9}$	$\frac{9}{368}$
56	-3	18	-3	-6	4	-2	$-\frac{1}{69}$	0	$-\frac{14}{23}$	$\frac{7}{69}$	$\frac{368}{245}$	$-\frac{184}{715}$	$-\frac{46}{534}$	$\frac{368}{2215}$
57	-2	5	2	4	-1	0	0	0	0	0	$\frac{92}{21}$	$-\frac{46}{15}$	$-\frac{23}{1}$	$\frac{92}{3}$
58	-2	12	2	-1	-2	-1	$-\frac{1}{69}$	0	$\frac{2}{23}$	$\frac{7}{69}$	$\frac{16}{227}$	$-\frac{8}{625}$	$-\frac{2}{78}$	$\frac{16}{11}$
59	-1	-4	-1	12	2	0	$\frac{27}{368}$	0	$\frac{1}{368}$	0	$\frac{92}{46}$	$-\frac{6}{23}$	$-\frac{19}{92}$	$\frac{4}{46}$
60	-1	1	-9	-1	27	-9	$\frac{8}{69}$	0	0	$-\frac{1}{69}$	$\frac{51}{46}$	$-\frac{3}{5}$	$-\frac{124}{35}$	$\frac{73}{46}$
61	-1	1	-1	-1	3	7	$\frac{1}{138}$	0	0	0	$-\frac{5}{736}$	$-\frac{17}{368}$	$-\frac{276}{93}$	$\frac{93}{736}$
62	-1	1	-1	11	3	-5	$-\frac{11853}{5336}$	$\frac{1}{23}$	$-\frac{209}{5336}$	$\frac{27}{2668}$	$\frac{93}{29}$	$\frac{1620}{28}$	$\frac{729}{52}$	$-\frac{459}{667}$
63	-1	1	7	-1	3	-1	0	0	0	$-\frac{1}{69}$	$\frac{28}{23}$	$-\frac{52}{2}$	$-\frac{10}{69}$	$-\frac{23}{3}$
64	-1	2	-9	0	20	-4	$\frac{1}{23}$	0	$-\frac{1}{23}$	0	$\frac{3}{46}$	$-\frac{23}{3}$	0	$-\frac{46}{3}$
65	-1	2	-1	0	-4	12	$\frac{1}{368}$	0	$-\frac{1}{368}$	0	$\frac{3}{736}$	$-\frac{25}{368}$	0	$-\frac{3}{736}$
66	-1	2	-1	6	8	-6	0	$\frac{1}{23}$	0	0	$\frac{736}{159}$	$-\frac{129}{184}$	$\frac{7}{23}$	$\frac{39}{184}$
67	-1	2	7	0	-4	4	0	0	0	0	0	1	0	0
68	-1	3	-1	-5	1	11	$\frac{1}{414}$	0	0	$\frac{1}{207}$	$-\frac{9}{736}$	$\frac{11}{368}$	$\frac{13}{276}$	$-\frac{31}{736}$
69	-1	3	-1	7	1	-1	0	0	$\frac{1}{46}$	0	$\frac{927}{736}$	$-\frac{909}{368}$	$-\frac{81}{92}$	$\frac{441}{736}$
70	-1	4	7	-4	-6	8	0	0	0	$\frac{1}{69}$	$-\frac{5}{23}$	$\frac{29}{23}$	$-\frac{16}{69}$	$\frac{10}{23}$
71	-1	8	-1	-6	2	6	0	0	0	$-\frac{1}{23}$	$\frac{5}{184}$	$-\frac{3}{92}$	$-\frac{7}{23}$	$\frac{59}{184}$
72	0	-1	-4	2	5	6	$\frac{1}{184}$	0	$\frac{1}{184}$	0	$-\frac{1}{368}$	$-\frac{5}{184}$	$-\frac{3}{46}$	$\frac{21}{368}$

73	0	0	-4	-3	10	5	$\frac{1}{207}$	0	0	$-\frac{1}{207}$	$\frac{1}{184}$	$-\frac{7}{92}$	$-\frac{4}{23}$	$\frac{31}{184}$
74	0	0	-4	9	10	-7	0	$\frac{1}{23}$	$-\frac{1}{23}$	0	$-\frac{63}{184}$	$\frac{153}{92}$	$\frac{36}{23}$	$-\frac{225}{184}$
75	0	0	4	3	-2	3	0	0	0	0	$\frac{1}{8}$	$\frac{1}{4}$	0	$-\frac{1}{8}$
76	0	1	-12	-2	27	-6	$\frac{2}{69}$	0	$-\frac{2}{23}$	$-\frac{1}{69}$	$\frac{7}{46}$	$-\frac{13}{23}$	$-\frac{52}{69}$	$\frac{31}{46}$
77	0	1	-4	-2	3	10	$\frac{1}{552}$	0	$-\frac{1}{184}$	0	$-\frac{3}{736}$	$-\frac{7}{368}$	$-\frac{17}{276}$	$\frac{46}{736}$
78	0	1	-4	4	15	-8	0	$\frac{1}{23}$	0	0	$-\frac{47}{92}$	$\frac{85}{46}$	$\frac{30}{23}$	$-\frac{77}{92}$
79	0	1	4	-2	3	2	0	0	0	$-\frac{1}{69}$	$\frac{5}{23}$	$-\frac{6}{23}$	$\frac{16}{69}$	$-\frac{10}{23}$
80	0	2	4	-1	-4	7	0	0	0	0	$-\frac{1}{8}$	$\frac{3}{4}$	0	$\frac{1}{8}$
81	0	6	-4	-3	4	5	0	0	$\frac{1}{23}$	0	$-\frac{1}{23}$	$\frac{10}{23}$	$\frac{17}{23}$	$-\frac{17}{23}$
82	0	7	4	-2	-3	2	0	0	0	0	2	-8	0	1
83	0	11	-4	-4	5	0	0	0	$-\frac{8}{23}$	0	$\frac{147}{92}$	$-\frac{321}{46}$	$-\frac{182}{23}$	$\frac{705}{92}$
84	0	14	4	-7	-4	1	$-\frac{1}{69}$	0	$\frac{2}{23}$	$\frac{88}{69}$	$-\frac{841}{92}$	$\frac{1727}{46}$	$-\frac{418}{23}$	$\frac{2389}{92}$
85	1	-2	1	6	0	2	0	0	0	0	$\frac{7}{32}$	$-\frac{5}{16}$	$-\frac{1}{4}$	$\frac{1}{32}$
86	1	-1	-7	7	17	-9	0	$\frac{1}{23}$	$-\frac{2}{23}$	0	$-\frac{285}{184}$	$\frac{435}{92}$	$\frac{65}{23}$	$-\frac{411}{184}$
87	1	-1	1	1	5	1	0	0	0	0	$\frac{1}{4}$	$-\frac{1}{2}$	0	$-\frac{1}{4}$
88	1	0	-7	-4	10	8	$\frac{1}{828}$	0	$-\frac{1}{92}$	$-\frac{1}{207}$	$\frac{3}{736}$	$-\frac{25}{368}$	$-\frac{47}{276}$	$\frac{133}{736}$
89	1	0	-7	2	22	-10	0	$\frac{1}{23}$	0	0	$-\frac{81}{46}$	$\frac{123}{23}$	$\frac{76}{23}$	$-\frac{119}{46}$
90	1	0	1	2	-2	6	0	0	0	0	$-\frac{3}{9}$	$\frac{16}{4}$	$\frac{1}{1}$	$-\frac{5}{2}$
91	1	0	9	2	-2	-2	0	$\frac{1}{23}$	0	0	$-\frac{32}{6}$	$-\frac{84}{23}$	$-\frac{16}{23}$	$-\frac{2}{23}$
92	1	5	1	1	-1	1	0	0	0	0	$\frac{3}{2}$	-6	-2	$\frac{3}{2}$
93	2	-4	-2	9	2	1	0	0	$\frac{1}{92}$	0	$\frac{111}{368}$	$-\frac{141}{184}$	$-\frac{13}{23}$	$\frac{93}{368}$
94	2	-2	-10	5	24	-11	0	$\frac{1}{23}$	$-\frac{4}{23}$	0	$-\frac{119}{46}$	$\frac{175}{23}$	$\frac{100}{23}$	$-\frac{167}{46}$
95	2	-2	-2	-1	12	-1	0	0	0	$\frac{1}{69}$	$\frac{13}{46}$	$-\frac{17}{23}$	$-\frac{16}{69}$	$-\frac{3}{46}$
96	2	-2	-2	5	0	5	0	0	$-\frac{1}{92}$	0	$-\frac{61}{736}$	$\frac{167}{368}$	$\frac{29}{92}$	$-\frac{163}{736}$
97	2	-2	6	5	0	-3	0	$\frac{1}{23}$	0	0	$-\frac{29}{23}$	$\frac{8}{23}$	$-\frac{16}{23}$	$-\frac{2}{23}$
98	2	-1	-10	0	29	-12	0	$\frac{1}{23}$	0	$\frac{1}{23}$	$-\frac{67}{23}$	$\frac{210}{23}$	$\frac{152}{23}$	$-\frac{133}{23}$
99	2	-1	-2	0	5	4	0	0	0	0	$-\frac{1}{3}$	$\frac{2}{8}$	$\frac{1}{2}$	$-\frac{7}{16}$
100	2	-1	6	0	5	-4	0	$\frac{1}{23}$	0	$\frac{1}{23}$	$-\frac{44}{23}$	$\frac{72}{23}$	$-\frac{32}{23}$	$\frac{28}{23}$
101	2	1	-2	-4	3	8	$\frac{97}{116}$	0	$\frac{5}{1044}$	$\frac{7}{174}$	$-\frac{230}{261}$	$-\frac{897}{29}$	$-\frac{175}{58}$	$-\frac{2}{29}$
102	2	1	-2	8	3	-4	$-\frac{12033}{2668}$	$\frac{1}{23}$	$-\frac{2668}{277}$	$-\frac{711}{1334}$	$\frac{90}{29}$	$\frac{6291}{227}$	$\frac{1161}{58}$	$\frac{162}{667}$
103	3	-3	-13	3	31	-13	0	$\frac{1}{23}$	$-\frac{8}{23}$	0	$-\frac{157}{46}$	$\frac{29}{23}$	$\frac{58}{35}$	$-\frac{215}{46}$
104	3	-3	-5	3	7	3	0	0	$-\frac{1}{46}$	0	$-\frac{53}{736}$	$\frac{127}{368}$	$\frac{23}{92}$	$-\frac{211}{736}$
105	3	-3	3	3	7	-5	0	$\frac{1}{23}$	0	0	$-\frac{52}{23}$	$\frac{100}{47}$	$-\frac{16}{23}$	$-\frac{2}{23}$
106	3	-2	-5	-2	12	2	0	0	0	$\frac{1}{69}$	$-\frac{23}{184}$	$\frac{23}{92}$	$\frac{53}{69}$	$-\frac{127}{184}$
107	3	-2	3	4	0	0	0	0	0	0	$\frac{1}{2}$	-2	0	$\frac{1}{2}$
108	3	-1	-5	-1	5	7	0	0	$\frac{1}{46}$	0	$\frac{7}{736}$	$\frac{11}{368}$	$\frac{11}{92}$	$-\frac{111}{736}$
109	3	0	3	0	-2	4	0	0	0	0	$\frac{1}{2}$	-2	0	$-\frac{1}{2}$
110	3	4	-5	-2	6	2	0	0	$-\frac{4}{23}$	0	$\frac{55}{184}$	$-\frac{137}{92}$	$-\frac{45}{23}$	$\frac{337}{184}$
111	3	7	3	-5	-3	3	0	0	0	$\frac{9}{23}$	$-\frac{20}{23}$	$\frac{116}{23}$	$-\frac{144}{23}$	$\frac{178}{23}$
112	3	11	-5	-7	5	1	0	0	$-\frac{32}{23}$	$-\frac{27}{23}$	3	$-\frac{438}{23}$	$-\frac{848}{23}$	$\frac{23}{23}$
113	4	-4	-16	1	38	-15	0	$\frac{1}{23}$	$-\frac{16}{23}$	$-\frac{1}{23}$	$-\frac{90}{23}$	$\frac{244}{23}$	$\frac{96}{23}$	$-\frac{82}{23}$
114	4	-4	-8	1	14	1	0	0	$-\frac{1}{23}$	0	$-\frac{15}{184}$	$\frac{23}{92}$	$\frac{6}{23}$	$-\frac{25}{184}$
115	4	-4	0	1	14	-7	0	$\frac{1}{23}$	0	$-\frac{1}{23}$	$-\frac{60}{23}$	$\frac{128}{23}$	0	$-\frac{32}{23}$
116	4	-4	0	7	2	-1	0	0	0	0	0	0	1	0
117	4	-3	0	2	7	-2	0	0	0	0	0	0	0	1
118	4	-2	0	3	0	3	0	0	0	0	$\frac{1}{2}$	-2	-1	$\frac{1}{2}$
119	4	3	0	2	1	-2	$-\frac{1}{69}$	0	$\frac{2}{23}$	$\frac{7}{69}$	$-\frac{601}{92}$	$\frac{1031}{46}$	$\frac{198}{23}$	$-\frac{25}{4}$
120	5	-6	-3	10	4	-2	0	0	$-\frac{1}{23}$	0	$-\frac{405}{736}$	$\frac{783}{368}$	$\frac{231}{92}$	$-\frac{675}{736}$
121	5	-5	-11	-1	21	-1	0	0	$-\frac{2}{23}$	$-\frac{1}{69}$	$-\frac{13}{184}$	$\frac{11}{92}$	$-\frac{17}{69}$	$\frac{77}{184}$
122	5	-5	-3	5	9	-3	0	0	0	0	$-\frac{1}{2}$	2	2	$-\frac{1}{2}$
123	5	-4	-3	0	14	-4	0	0	0	$-\frac{1}{23}$	$-\frac{8}{23}$	$\frac{28}{23}$	$\frac{16}{23}$	$\frac{16}{23}$
124	5	-4	-3	6	2	2	0	0	$\frac{1}{23}$	0	$\frac{405}{736}$	$-\frac{783}{368}$	$-\frac{139}{92}$	$\frac{675}{736}$
125	5	1	-3	5	3	-3	$-\frac{1}{69}$	0	$-\frac{6}{23}$	$\frac{7}{69}$	$-\frac{148}{23}$	$\frac{493}{23}$	$\frac{246}{23}$	$-\frac{209}{23}$
126	6	-6	-6	3	16	-5	0	0	0	0	-1	4	4	-2
127	6	-5	-6	4	9	0	0	0	$\frac{2}{23}$	0	$\frac{221}{368}$	$-\frac{415}{184}$	$-\frac{93}{46}$	$\frac{491}{368}$
128	6	-3	-6	0	7	4	0	0	$-\frac{2}{23}$	0	$-\frac{37}{368}$	$\frac{47}{184}$	$\frac{1}{46}$	$\frac{61}{368}$

129	6	0	2	-3	-2	5	0	0	0	$\frac{3}{23}$	$\frac{1}{23}$	$\frac{8}{23}$	$-\frac{48}{23}$	$\frac{44}{23}$
130	6	4	-6	-5	6	3	0	0	$-\frac{16}{23}$	$-\frac{9}{46}$	$\frac{49}{46}$	-7	$-\frac{312}{23}$	$\frac{625}{46}$
131	6	5	2	-4	-1	0	$-\frac{1}{69}$	0	$\frac{2}{23}$	$-\frac{74}{69}$	$\frac{361}{92}$	$\frac{335}{46}$	$\frac{446}{23}$	$-\frac{1883}{92}$
132	6	9	-6	-6	7	-2	$-\frac{1}{69}$	0	$\frac{130}{23}$	$\frac{250}{69}$	$\frac{1465}{92}$	$\frac{46}{3839}$	$\frac{23}{3102}$	$-\frac{12347}{92}$
133	7	-7	-9	1	23	-7	0	0	0	$\frac{1}{23}$	$\frac{38}{23}$	$\frac{46}{23}$	$\frac{156}{23}$	$-\frac{108}{23}$
134	7	-6	-9	2	16	-2	0	0	$\frac{4}{23}$	0	$\frac{129}{184}$	$-\frac{231}{92}$	$-\frac{47}{23}$	$\frac{215}{184}$
135	7	-6	-1	8	4	-4	0	$\frac{1}{23}$	0	0	$-\frac{81}{46}$	$\frac{54}{23}$	$-\frac{108}{23}$	$-\frac{27}{46}$
136	7	-4	-1	4	2	0	0	0	0	0	$-\frac{3}{2}$	6	4	$-\frac{2}{3}$
137	7	3	-1	-1	1	-1	$-\frac{1}{69}$	0	$\frac{2}{23}$	$\frac{7}{69}$	$\frac{601}{92}$	$\frac{1031}{46}$	$\frac{750}{23}$	$-\frac{133}{4}$
138	8	-8	-4	11	6	-5	0	$\frac{1}{23}$	$\frac{4}{23}$	0	81	$-\frac{567}{92}$	$-\frac{270}{23}$	$\frac{567}{184}$
139	8	-7	-12	0	23	-4	0	0	$\frac{8}{23}$	$\frac{1}{23}$	$\frac{184}{3}$	$-\frac{103}{4}$	$-\frac{18}{23}$	$-\frac{33}{92}$
140	8	-7	-4	6	11	-6	0	$\frac{1}{23}$	0	0	$-\frac{6}{23}$	$\frac{46}{84}$	$-\frac{23}{200}$	$\frac{21}{23}$
141	8	-6	-4	7	4	-1	0	0	$-\frac{4}{23}$	0	$\frac{405}{184}$	$\frac{783}{92}$	$\frac{162}{23}$	$-\frac{675}{184}$
142	9	-9	-7	9	13	-7	0	$\frac{1}{23}$	$\frac{8}{23}$	0	$\frac{243}{92}$	$-\frac{675}{46}$	$-\frac{432}{23}$	$\frac{27}{4}$
143	9	-8	-7	4	18	-8	0	$\frac{1}{23}$	0	0	$\frac{40}{92}$	$\frac{46}{268}$	$-\frac{23}{384}$	$\frac{4}{136}$
144	9	-3	-7	-3	7	5	0	0	$-\frac{8}{23}$	$-\frac{3}{23}$	$\frac{23}{5}$	$-\frac{61}{46}$	$-\frac{23}{88}$	$\frac{23}{17}$
145	9	-2	1	-2	0	2	0	0	0	0	$-\frac{9}{23}$	$-\frac{26}{68}$	$\frac{144}{23}$	$-\frac{86}{23}$
146	9	2	-7	-4	8	0	0	0	$\frac{64}{23}$	$\frac{27}{23}$	$\frac{78}{23}$	$\frac{528}{23}$	$\frac{1024}{23}$	$-\frac{1014}{23}$
147	10	-4	-2	1	2	1	0	0	0	0	-3	12	16	-12
148	10	-10	-10	7	20	-9	0	$\frac{1}{23}$	$\frac{16}{23}$	0	$\frac{255}{46}$	$-\frac{591}{23}$	$-\frac{664}{23}$	$\frac{579}{46}$
149	10	-9	-10	2	25	-10	0	$\frac{1}{23}$	0	$-\frac{3}{23}$	$\frac{108}{23}$	-24	$-\frac{704}{23}$	16
150	11	-11	-13	5	27	-11	0	$\frac{1}{23}$	$\frac{32}{23}$	0	$\frac{215}{23}$	$-\frac{914}{23}$	$-\frac{944}{23}$	$\frac{443}{23}$
151	11	-8	-5	8	6	-4	$-\frac{1}{69}$	0	$\frac{18}{23}$	$\frac{7}{69}$	$\frac{623}{92}$	$-\frac{1363}{46}$	$-\frac{726}{23}$	$\frac{23}{1189}$
152	12	-12	-16	3	34	-13	0	$\frac{1}{23}$	$\frac{64}{23}$	$\frac{3}{23}$	14	$-\frac{1276}{23}$	$-\frac{1184}{23}$	$\frac{92}{518}$
153	12	-5	-8	-2	9	2	0	0	$\frac{33}{23}$	$\frac{9}{23}$	17	22	$\frac{216}{23}$	$-\frac{274}{23}$
154	13	-6	-3	2	4	-2	$-\frac{1}{69}$	0	$\frac{2}{69}$	$\frac{7}{69}$	$\frac{1055}{92}$	$-\frac{2281}{46}$	$-\frac{1458}{23}$	$\frac{155}{4}$
155	14	-8	-6	5	6	-3	$-\frac{1}{69}$	0	$\frac{66}{69}$	$\frac{7}{69}$	$\frac{1811}{92}$	$-\frac{3577}{46}$	$-\frac{1842}{23}$	$\frac{3997}{92}$
156	16	-6	-4	-1	4	-1	$-\frac{1}{69}$	0	$\frac{2}{69}$	$-\frac{236}{69}$	$\frac{3431}{92}$	$-\frac{7681}{46}$	$-\frac{4578}{23}$	$\frac{13717}{92}$