

第一次编程练习报告

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一、编程练习 1——Eratosthenes 筛法打印 1 000 000 内所有素数及个数

```
#include<iostream>
using namespace std;

const int max_number = 1000000; //求素数的范围
int* p = new int[max_number + 1]; //存储该范围内所有数的数组

void eratosthenes(int* p) { //Eratosthenes筛选法
    for (int i = 2; i <= sqrt(max_number); i++)
        for (int j = 2 * i; j <= max_number; j += i) //将i的倍数都赋成0
            p[j] = 0;
}

int main() {
    for (int i = 0; i <= max_number; i++) //初始化数组
        p[i] = i;
    p[1] = 0;
    eratosthenes(p);
    int count = 0;
    for (int i = 2; i <= max_number; i++) { //遍历数组
        if (p[i] != 0) { //输出不为0的数(即素数)
            cout << p[i] << ", ";
            count++;
        }
    }
    cout << endl;
    cout << "Total:" << count;
    return 0;
}
```

➤ 说明部分：

要得到自然数 n 以内的全部素数，必须把不大于根号 n 的所有素数的倍数剔除，剩下的就是素数。

算法流程：

Step1:将[2, 1000000]区间排成一列

Step2:标出表中第一个数，筛去其所有的倍数。

不断重复第二步，剩余的就是[2, 1000000]中所有的素数。

➤ 运行示例：

```
Microsoft Visual Studio 调试
2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53, 59, 61, 67, 71, 73, 79, 83, 89, 97, 101, 103, 107, 109, 113, 127, 131, 137, 139, 149, 151, 157, 163, 167, 173, 179, 181, 191, 193, 197, 199, 211, 223, 227, 229, 233, 239, 241, 251, 257, 263, 269, 271, 277, 281, 283, 293, 307, 311, 313, 317, 331, 337, 347, 349, 353, 359, 367, 373, 379, 383, 389, 397, 401, 409, 419, 421, 431, 433, 439, 443, 449, 457, 461, 463, 467, 479, 487, 491, 499, 503, 509, 521, 523, 541, 547, 557, 563, 569, 571, 577, 587, 593, 599, 601, 607, 613, 617, 619, 631, 641, 643, 647, 653, 659, 661, 673, 677, 683, 691, 701, 709, 719, 727, 733, 739, 743, 751, 757, 761, 769, 773, 787, 797, 809, 811, 821, 823, 827, 829, 839, 853, 857, 859, 863, 877, 881, 883, 887, 907, 911, 919, 929, 937, 941, 947, 953, 967, 971, 977, 983, 991, 997, 1009, 1013, 1019, 1021, 1031, 1033, 1039, 1049, 1051, 1061, 1063, 1069, 1087, 1091, 1093, 1103, 1109, 1117, 1123, 1129, 1151, 1153, 1163, 1171, 1181, 1187, 1193, 1201, 1213, 1217, 1223, 1229, 1231, 1237, 1249, 1259, 1277, 1279, 1283, 1289, 1291, 1297, 1301, 1303, 1307, 1319, 1321, 1327, 1361, 1367, 1373, 1381, 1399, 1409, 1423, 1427, 1429, 1433, 1439, 1447, 1451, 1453, 1459, 1471, 1481, 1483, 1487, 1489, 1493, 1499, 1511, 1523, 1531, 1543, 1549, 1553, 1559, 1567, 1571, 1579, 1583, 1597, 1601, 1607, 1609, 1613, 1619, 1621, 1627, 1637, 1657, 1663, 1667, 1669, 1693, 1697, 1699, 1709, 1721, 1723, 1733, 1741, 1747, 1753, 1759, 1777, 1783, 1787, 1789, 1801, 1811, 1823, 1831, 1847, 1861, 1867, 1871, 1873, 1877, 1879, 1889, 1901, 1907, 1913, 1931, 1933, 1949, 1951, 1973, 1979, 1987, 1993, 1997, 1999, 2003, 2011, 2017, 2027, 2029, 2039, 2053, 2063, 2069, 2081, 2083, 2087, 2089, 2099, 2111, 2113, 2129, 2131, 2137, 2141, 2143, 2153, 2161, 2179, 2203, 2207, 2213, 2221, 2237, 2239, 2243, 2251, 2267, 2269, 2273, 2281, 2287, 2293, 2297, 2309, 2311, 2333, 2339, 2341, 2347, 2351, 2357, 2371, 2373, 2381, 2383, 2389, 2393, 2399, 2411, 2417, 2423, 2437, 2441, 2447, 2459, 2467, 2473, 2477, 2503, 2521, 2531, 2539, 2543, 2549, 2551, 2557, 2579, 2591, 2593, 2609, 2617, 2621, 2633, 2647, 2657, 2659, 2663, 2671, 2677, 2683, 2687, 2689, 2693, 2699, 2707, 2711, 2713, 2719, 2729, 2731, 2741, 2749, 2753, 2767, 2777, 2789, 2791, 2797, 2801, 2803, 2819, 2833, 2837, 2843, 2851, 2857, 2861, 2879, 2887, 2897, 2903, 2909, 2917, 2927, 2939, 2953, 2957, 2963, 2969, 2971, 2999, 3001, 3011, 3019, 3023, 3037, 3041, 3049, 3061, 3067, 3079, 3083, 3089, 3109, 3119, 3121, 3137, 3163, 3167, 3169, 3181, 3187, 3191, 3203, 3209, 3217, 3221, 3229, 3251, 3253, 3257, 3259, 3271, 3299, 3301, 3307, 3313, 3319, 3323, 3329, 3331, 3343, 3347, 3359, 3361, 3371, 3373, 3389, 3391, 3407, 3413, 3433, 3449, 3457, 3461, 3463, 3467, 3469, 3491, 3499, 3511, 3517, 3527, 3529, 3533, 3539, 3541, 3547, 3557, 3559, 3571, 3581, 3583, 3593, 3607, 3613, 3617, 3623, 3631, 3637, 3643, 3659, 3671, 3673, 3677, 3691, 3697, 3701, 3709, 3719, 3727, 3733, 3739, 3761, 3767, 3769, 3779, 3793, 3797, 3803, 3821, 3823, 3833, 3847, 3851, 3853, 3863, 3877, 3881, 3889, 3907, 3911, 3917, 3919, 3929, 3929, 3931, 3943, 3947, 3967, 3989, 4001, 4003, 4007, 4013, 4019, 4021, 4027, 4049, 4051, 4057, 4073, 4079, 4091, 4093, 4099, 4111, 4127, 4129, 4133, 4139, 4153, 4157, 4159, 4177, 4201, 4211, 4217, 4219, 4229, 4231, 4241, 4243, 4253, 4259, 4261, 4271, 4273, 4283, 4289, 4297, 4327, 4329, 4339, 4349, 4357, 4363, 4373, 4391, 4397, 4409, 4421, 4423, 4441, 4447, 4451, 4457, 4463, 4481, 4483, 4493, 4507, 4513, 4517, 4519, 4523, 4547, 4549, 4561, 4567, 4583, 4591, 4597, 4603, 4621, 4637, 4639, 4643, 4649, 4651, 4657, 4663, 4673, 4679, 4691, 4703, 4721, 4723, 4729, 4733, 4751, 4759, 4783, 4787, 4789, 4793, 4799, 4801, 4813, 4817, 4831, 4861, 4871, 4877, 4889, 4903, 4909, 4919, 4931, 4933, 4937, 4943, 4951, 4957, 4967, 4969, 4973, 4987, 4993, 4999, 5003, 5009, 5011, 5021, 5023, 5039, 5051, 5059, 5077, 5081, 5087, 5099, 5101, 5107, 5113, 5119, 5147, 5153, 5167, 5171, 5179, 5189, 5197, 5209, 5227, 5231, 5233, 5237, 5261, 5273, 5279, 5281, 5297, 5303, 5309, 5323, 5333, 5347, 5351, 5381, 5387, 5393, 5399, 5407, 5413, 5417, 5419, 5421, 5437, 5441, 5443, 5449, 5471, 5477, 5479, 5483, 5501, 5503, 5507, 5519, 5521, 5527, 5531, 5557, 5563, 5569, 5573, 5581, 5591, 5623, 5639, 5641, 5647, 5651, 5653, 5657, 5659, 5669, 5683, 5689, 5693, 5701, 5711, 5717, 5737, 5741, 5743, 5749, 5779, 5783, 5789, 5797, 5801, 5803, 5807, 5813, 5819, 5821, 5827, 5831, 5833, 5837, 5843, 5849, 5851, 5853, 5857, 5863, 5869, 5871, 5873, 5877, 5881, 5883, 5887, 5891, 5893, 5897, 5901, 5903, 5907, 5911, 5913, 5917, 5921, 5923, 5927, 5931, 5933, 5937, 5941, 5943, 5947, 5951, 5953, 5957, 5963, 5969, 5971, 5973, 5977, 5981, 5983, 5987, 5991, 5993, 5997, 6001, 6003, 6007, 6011, 6013, 6017, 6021, 6023, 6027, 6031, 6033, 6037, 6041, 6043, 6047, 6051, 6053, 6057, 6061, 6063, 6067, 6071, 6073, 6077, 6081, 6083, 6087, 6091, 6093, 6097, 6101, 6103, 6107, 6111, 6113, 6117, 6121, 6123, 6127, 6131, 6133, 6137, 6141, 6143, 6147, 6151, 6153, 6157, 6161, 6163, 6167, 6171, 6173, 6177, 6181, 6183, 6187, 6191, 6193, 6197, 6201, 6203, 6207, 6211, 6213, 6217, 6221, 6223, 6227, 6229, 6233, 6237, 6241, 6243, 6247, 6251, 6253, 6257, 6261, 6263, 6267, 6269, 6271, 6273, 6277, 6281, 6283, 6287, 6291, 6293, 6297, 6301, 6303, 6307, 6311, 6313, 6317, 6321, 6323, 6327, 6331, 6333, 6337, 6341, 6343, 6347, 6351, 6353, 6357, 6361, 6363, 6367, 6371, 6373, 6377, 6381, 6383, 6387, 6391, 6393, 6397, 6401, 6403, 6407, 6411, 6413, 6417, 6421, 6423, 6427, 6431, 6433, 6437, 6441, 6443, 6447, 6451, 6453, 6457, 6461, 6463, 6467, 6471, 6473, 6477, 6481, 6483, 6487, 6491, 6493, 6497, 6501, 6503, 6507, 6511, 6513, 6517, 6521, 6523, 6527, 6531, 6533, 6537, 6541, 6543, 6547, 6551, 6553, 6557, 6561, 6563, 6567, 6571, 6573, 6577, 6581, 6583, 6587, 6591, 6593, 6597, 6601, 6603, 6607, 6611, 6613, 6617, 6621, 6623, 6627, 6631, 6633, 6637, 6641, 6643, 6647, 6651, 6653, 6657, 6661, 6663, 6667, 6671, 6673, 6677, 6681, 6683, 6687, 6691, 6693, 6697, 6701, 6703, 6707, 6711, 6713, 6717, 6721, 6723, 6727, 6731, 6733, 6737, 6741, 6743, 6747, 6751, 6753, 6757, 6761, 6763, 6767, 6771, 6773, 6777, 6781, 6783, 6787, 6791, 6793, 6797, 6801, 6803, 6807, 6811, 6813, 6817, 6821, 6823, 6827, 6831, 6833, 6837, 6841, 6843, 6847, 6851, 6853, 6857, 6861, 6863, 6867, 6871, 6873, 6877, 6881, 6883, 6887, 6891, 6893, 6897, 6901, 6903, 6907, 6911, 6913, 6917, 6921, 6923, 6927, 6931, 6933, 6937, 6941, 6943, 6947, 6951, 6953, 6957, 6961, 6963, 6967, 6971, 6973, 6977, 6981, 6983, 6987, 6991, 6993, 6997, 7001, 7003, 7007, 7011, 7013, 7017, 7021, 7023, 7027, 7031, 7033, 7037, 7041, 7043, 7047, 7051, 7053, 7057, 7061, 7063, 7067, 7071, 7073, 7077, 7081, 7083, 7087, 7091, 7093, 7097, 7101, 7103, 7107, 7111, 7113, 7117, 7121, 7123, 7127, 7131, 7133, 7137, 7141, 7143, 7147, 7151, 7153, 7157, 7161, 7163, 7167, 7171, 7173, 7177, 7181, 7183, 7187, 7191, 7193, 7197, 7201, 7203, 7207, 7211, 7213, 7217, 7221, 7223, 7227, 7231, 7233, 7237, 7241, 7243, 7247, 7251, 7253, 7257, 7261, 7263, 7267, 7271, 7273, 7277, 7281, 7283, 7287, 7291, 7293, 7297, 7301, 7303, 7307, 7311, 7313, 7317, 7321, 7323, 7327, 7331, 7333, 7337, 7341, 7343, 7347, 7351, 7353, 7357, 7361, 7363, 7367, 7371, 7373, 7377, 7381, 7383, 7387, 7391, 7393, 7397, 7401, 7403, 7407, 7411, 7413, 7417, 7421, 7423, 7427, 7431, 7433, 7437, 7441, 7443, 7447, 7451, 7453, 7457, 7461, 7463, 7467, 7471, 7473, 7477, 7481, 7483, 7487, 7491, 7493, 7497, 7501, 7503, 7507, 7511, 7513, 7517, 7521, 7523, 7527, 7531, 7533, 7537, 7541, 7543, 7547, 7551, 7553, 7557, 7561, 7563, 7567, 7571, 7573, 7577, 7581, 7583, 7587, 7591, 7593, 7597, 7601, 7603, 7607, 7611, 7613, 7617, 7621, 7623, 7627, 7631, 7633, 7637, 7641, 7643, 7647, 7651, 7653, 7657, 7661, 7663, 7667, 7671, 7673, 7677, 7681, 7683, 7687, 7691, 7693, 7697, 7701, 7703, 7707, 7711, 7713, 7717, 7721, 7723, 7727, 7731, 7733, 7737, 7741, 7743, 7747, 7751, 7753, 7757, 7761, 7763, 7767, 7771, 7773, 7777, 7781, 7783, 7787, 7791, 7793, 7797, 7801, 7803, 7807, 7811, 7813, 7817, 7821, 7823, 7827, 7831, 7833, 7837, 7841, 7843, 7847, 7851, 7853, 7857, 7861, 7863, 7867, 7871, 7873, 7877, 7881, 7883, 7887, 7891, 7893, 7897, 7901, 7903, 7907, 7911, 7913, 7917, 7921, 7923, 7927, 7931, 7933, 7937, 7941, 7943, 7947, 7951, 7953, 7957, 7961, 7963, 7967, 7971, 7973, 7977, 7981, 7983, 7987, 7991, 7993, 7997, 8001, 8003, 8007, 8011, 8013, 8017, 8021, 8023, 8027, 8031, 8033, 8037, 8041, 8043, 8047, 8051, 8053, 8057, 8061, 8063, 8067, 8071, 8073, 8077, 8081, 8083, 8087, 8091, 8093, 8097, 8101, 8103, 8107, 8111, 8113, 8117, 8121, 8123, 8127, 8131, 8133, 8137, 8141, 8143, 8147, 8151, 8153, 8157, 8161, 8163, 8167, 8171, 8173, 8177, 8181, 8183, 8187, 8191, 8193, 8197, 8201, 8203, 8207, 8211, 8213, 8217, 8221, 8223, 8227, 8231, 8233, 8237, 8241, 8243, 8247, 8251, 8253, 8257, 8261, 8263, 8267, 8271, 8273, 8277, 8281, 8283, 8287, 8291, 8293, 8297, 8301, 8303, 8307, 8311, 8313, 8317, 8321, 8323, 8327, 8331, 8333, 8337, 8341, 8343, 8347, 8351, 8353, 8357, 8361, 8363, 8367, 8371, 8373, 8377, 8381, 8383, 8387, 8391, 8393, 8397, 8401, 8403, 8407, 8411, 8413, 8417, 8421, 8423, 8427, 8431, 8433, 8437, 8441, 8443, 8447, 8451, 8453, 8457, 8461, 8463, 8467, 8471, 8473, 8477, 8481, 8483, 8487, 8491, 8493, 8497, 8501, 8503, 8507, 8511, 8513, 8517, 8521, 8523, 8527, 8531, 8533, 8537, 8541, 8543, 8547, 8551, 8553, 8557, 8561, 8563, 8567, 8571, 8573, 8577, 8581, 8583, 8587, 8591, 8593, 8597, 8601, 8603, 8607, 8611, 8613, 8617, 8621, 8623, 8627, 8631, 8633, 8637, 8641, 8643, 8647, 8651, 8653, 8657, 8661, 8663, 8667, 8671, 8673, 8677, 8681, 8683, 8687, 8691, 8693, 8697, 8701, 8703, 8707, 8711, 8713, 8717, 8721, 8723, 8727, 8731, 8733, 8737, 8741, 8743, 8747, 8751, 8753, 8757, 8761, 8763, 8767, 8771, 8773, 8777, 8781, 8783, 8787, 8791, 8793, 8797, 8801, 8803, 8807, 8811, 8813, 8817, 8821, 8823, 8827, 8831, 8833, 8837, 8841, 8843, 8847, 8851, 8853, 8857, 8861, 8863, 8867, 8871, 8873, 8877, 8881, 8883, 8887, 8891, 8893, 8897, 8901, 8903, 8907, 8911, 8913, 8917, 8921, 8923, 8927, 8931, 8933, 8937, 8941, 8943, 8947, 8951, 8953, 8957, 8961, 8963, 8967, 8971, 8973, 8977, 8981, 8983, 8987, 8991, 8993, 8997, 9001, 9003, 9007, 9011, 9013, 9017, 9021, 9023, 9027, 9031, 9033, 9037, 9041, 9043, 9047, 9051, 9053, 9057, 9061, 9063, 9067, 9071, 9073, 9077, 9081, 9083, 9087, 9091, 9093, 9097, 9101, 9103, 9107, 9111, 9113, 9117, 9121, 9123, 9127, 9131, 9133, 9137, 9141, 9143, 9147, 9151, 9153, 9157, 9161, 9163, 9167, 9171, 9173, 9177, 9181, 9183, 9187, 9191, 9193, 9197, 9201, 9203, 9207, 9211, 9213, 9217, 9221, 9223, 9227, 9231, 9233, 9237, 9241, 9243, 9247, 9251, 9253, 9257, 9261, 9263, 9267, 9271, 9273, 9277, 9281, 9283, 9287, 9291, 9293, 9297, 9301, 9303, 9307, 9311, 9313, 9317, 9321, 9323, 9327, 9331, 9333, 9337, 9341, 9343, 9347, 9351, 9353, 9357, 9361, 9363, 9367, 9371, 9373, 9377, 9381, 9383, 9387, 9391, 9393, 9397, 9401, 9403, 9407, 9411, 9413, 9417, 9421, 9423, 9427, 9431, 9433, 9437, 9441, 9443, 9447, 9451, 9453, 9457, 9461, 9463, 9467, 9471, 9473, 9477, 9481, 9483, 9487, 9491, 9493, 9497, 9501, 9503, 9507, 9511, 9513, 9517, 9521, 9523, 9527, 9531, 9533, 9537, 9541, 9543, 9547, 9551, 9553, 9557, 9561, 9563, 9567, 9571, 9573, 9577, 9581, 9583, 9587, 9591, 9593, 9597, 9601, 9603, 9607, 9611, 9613, 9617, 9621, 9623, 9627, 9631, 9633, 9637, 9641, 9643, 9647, 9651, 9653, 9657, 9661, 9663, 9667, 9671, 9673, 9677, 9681, 9683, 9687, 9691, 9693, 9697, 9701, 9703, 9707, 9711, 9713, 9717, 9721, 9723, 9727, 9731, 9733, 9737, 9741, 9743, 9747, 9751, 9753, 9757, 9761, 9763, 9767, 9771, 9773, 9777, 9781, 9783, 9787, 9791, 9793, 9797, 9801, 9803, 9807, 9811, 9813, 9817, 9821, 9823, 9827, 9831, 9833, 9837, 9841, 9843, 9847, 9851, 9853, 9857, 9861, 9863, 9867, 9871, 9873, 9877, 9881, 9883, 9887, 9891, 9893, 9897, 9901, 9903, 9907, 9911, 9913, 9917, 9921, 9923, 9927, 9931, 9933, 9937, 9941, 9943, 9947, 9951, 9953, 9957, 9961, 9963, 9967, 9971, 9973, 9977, 9981, 9983, 9987, 9991, 9993, 9997, 10001, 10003, 10007, 10011, 10013, 10017, 10021, 10023, 10027, 10031, 10033, 10037, 10041, 10043, 10047, 10051, 10053, 10057, 10061, 10063, 10067, 10071, 10073, 10077, 10081, 10083, 10087, 10091, 10093, 10097, 10101, 10103, 10107, 10111, 10113, 10117, 101
```

Eratosthenes 筛法的时间复杂度为 $O(n \log \log n)$, 普通算法的时间复杂度是 $O(n \log n)$

b. 递归调用该算法求更大范围素数进行优化

```
#include <iostream>
using namespace std;
int fun(int n, int i) {
    //相当于for循环的那一环节
    if (i * i > n) { //在 $\sqrt{n}$ 的范围内搜索
        return 1;
    }
    if (n % i == 0) { //取模为0 return
        return 0;
    }
    fun(n, i + 1); //递归
}
int isprim(int n) { //判断是不是素数, 大于2且fun函数返回的值为1, 则为素数
    return n >= 2 && fun(n, 2);
}

int main() {
    int count = 0;
    for (int i = 1; i <= 1000000; i++) {
        if (isprim(i)) {
            cout << i << ", ";
            count++;
        }
    }
    cout << count;
}
```

c. 求更大的素数 (如 2^{512} 数量级) 该方法是否适用? 会引入哪些新的问题?

不适用。(1) 时间和存储空间: 由于 Eratosthenes 筛法需要存储所有被筛出的数字, 对于比较大的数字, 很容易占用大量的计算机内存; 另外, 由于计算量比较大, Eratosthenes 筛法也需要很长的时间来

完成。(2) 不可分割性：由于 Eratosthenes 筛法中的部分运算是不可分割的，因此在某些情况下会导致不能正确处理结果。

二、编程练习 2——编写程序计算最大公因数和最小公倍数

```
#include<iostream>
using namespace std;
void swap(int& a, int& b) {
    int tmp = a;
    a = b;
    b = tmp;
}
int gcd(int a, int b) { //利用辗转相除法求最大公因数
    if (a < b) //a为较小的那个数
        swap(a, b); //交换ab, 让a为较大的数
    int r = a % b; //余数
    while (r != 0) { //当余数不为0时
        a = b;
        b = r;
        r = a % b;
    }
    return b;
}
int lcm(int a, int b) { //最小公倍数
    return a * b / gcd(a, b);
}
int main() {
    int a, b;
    cout << "a=";
    cin >> a;
    cout << "b=";
    cin >> b;
    cout << "gcd(a,b)=" << gcd(a, b) << endl;
    cout << "lcm(a,b)=" << lcm(a, b) << endl;
}
```

➤ 说明部分：

辗转相除法，是求最大公因数的一种方法。它的具体做法是：用较小数除较大数，再用出现的余数（第一余数）去除除数，再用出现的余数（第二余数）去除第一余数，如此反复，直到最后余数是 0 为

止。最后的除数就是这两个数的最大公因数。

求出最大公因数后，通过公式求出最小公倍数，最小公倍数=两数乘积/最大公因数。

➤ 运行示例：



```
Microsoft Visual Studio 调试 × +
a=9876
b=6789
gcd(a,b)=3
lcm(a,b)=22349388
```

三、编程练习 3——编写程序实现算术基本定理

```
#include<iostream>
using namespace std;
void deposition(int n) { //求素因子分解
    for (int i = 2; i <= n; i++) { //遍历
        int count = 0; //count次幂
        while (n % i == 0) { //计算i对应的count
            count++; //次数+1
            n /= i; //除掉因子
        }
        if (count != 0) { //输出分解式
            cout << i << "^" << count;
            if (n != 1)
                cout << "*";
            else break;
        }
    }
}

int main() {
    int n;
    cout << "Please input n(n>0):";
    cin >> n;
    cout << n << "=";
    deposition(n);
}
```

➤ 说明部分：

求素因子分解的过程：从 2 开始遍历，如果 n 取模 i 为 0，说明 i

整除 n ，再用 n 除以 i ，直至不能整除，计算出 i 的个数。以此类推求出素因子的值以及个数。

➤ 运行示例：



```
Microsoft Visual Studio 调试 × + ∨  
Please input n(n>0):888  
888=2^3*3^1*37^1
```