Algorithms - Series Two(iv)

Two more ways to calculate Pi

First, let's look at Euler's method. In this approach, we use a form of the zeta function:

$$\frac{\pi^2}{6} = \frac{1}{1^2} + \frac{1}{2^2} + \frac{1}{3^2} \cdots$$

Here's my "main()" function:

```
def main():
    print("Euler's method for calculating pi.")
    digits = int(input("How many digits? "))
    err = 10 ** - (2 * digits + 1)
    euler = zeta(2,err)
    string = "%." + str(digits) + 'f'
    print(string % (euler * 6) ** 0.5)

if __name__ == "__main__":
    main()
```

This is fairly simple. I ask the user how many digits they want. This program doesn't use the "Decimal()" data-type so it's only really good for fairly small numbers of decimal places. We use the number of digits to create a value for "err" that is small enough so that all the digits should be correct. Then we pass 2 and the error to the zeta function. The slightly awkward bit is that I have to build up the string for the formatted print statement as it will give an error if I try to do it within print() itself.

Here's the zeta function:

```
def zeta(expt, err):
    """Zeta function. Takes the exponent and the error."""
    i = old = 1
    new = 0
    while abs(old - new) > err:
        old = new
        new += 1 / i ** expt
        i += 1
    return new
```

Okay, that's easy enough.

Let's try another method now. This one is not quite as accurate, but it is fun. It's named after Ernesto Cesàro, the Italian mathematician and it relies on probability. The idea is that if you take two random whole numbers, the probability that they will be coprime is:

$$\frac{6}{\pi^2}$$

Here's my code for this example:

```
# cesaro.py
# Uses monte-carlo method to calculate pi.

import random, math

def main():
    print("*** Cesaro's method for pi. ***")
    while 1:
        t = int(input("How many trials? "))
        if t == 0:
            return
        else:
            print(math.sqrt(6 / monte_carlo(cesaro, t)))

def monte_carlo(f, t):
    """Takes a function and a number of trials.
    Returns the ratio of passed trials to the total number of trials."""
    passed = 0
    for i in range(t):
        if f():
            passed += 1
    return passed / t

def cesaro():
    """Returns true if two random numbers are coprime."""
    return 1 == gcd(random.randint(1, 999999), random.randint(1, 999999))

def gcd(a,b):
    """Takes two integers and returns gcd."""
    if b == 0:
        return a
    else:
        return gcd(b, a % b)

if __name__ == "__main__":
    main()
```

Sample Output:

```
*** Cesaro's method for pi. ***
How many trials? 100000000
3.14156085159
How many trials?
```

You may need to be fairly patient if you are hoping for an accurate result.
This was the output I got after one hundred million trials!

Happy Hacking!