

# Homework2

September 14, 2021

## 1 Homework Week 2

### 1.1 Nth Root Calculator

```
[3]:                                 # get our inputs
radicand  = float(input("Radicand? ( )"))
n         = float(input("n?"))
iterations = int(input("Number of Iterations?"))

                                # start by guessing upper and lower
    ↳ bounds for the value
tooBig    = radicand + 1        # radicand + 1: because roots of
    ↳ numbers smaller than 1 can be larger than the radicand
tooSmall  = 0                  # since we're not dealing with
    ↳ complex numbers or negative radicands, no root can be negative

for i in range(0, iterations):
    midBounds = (tooBig + tooSmall) / 2    # value should be between the bounds
                                           # average our two bounds

    radicandEstimate = midBounds ** n      # raise this average to the n power

                                           # compare that estimate to our known
    ↳ radicand, and adjust upper or lower bounds accordingly
    if radicandEstimate < radicand:
        tooSmall = midBounds
    elif radicandEstimate > radicand:
        tooBig = midBounds
    elif radicandEstimate == radicand:
        break

print((tooBig + tooSmall) / 2)
# this one becomes very accurate with more iterations
# in fact, with enough iterations, it is accurate to every decimal place
```

Radicand? ( ) 5

n? 3

Number of Iterations? 100

1.709975946676697

## 1.2 e Approximator

e 2.718281828459045 (from Google)

```
[8]: # A smaller dx and more iterations should give more accuracy
# But this is not necessarily the case
# The following values give the most accurate answer:

dx = 10 ** -8
iterations = 25

# 10^-8 gave the best result, not 10^-7, not 10^-9
# And iterations stopped becoming more accurate at around 23
# Overall, I was able to to get around 7 decimal places of accuracy

# According to the assignment, we are technically supposed to start with only
    ↳ one assumption, that  $(d/dx) e^x = e^x$ ,
# I think it's also safe assume that e is between 3 and 2
tooBig = 3
tooSmall = 2

# if  $(d/dx) e^x = e^x$ , then the slope at  $x = 1$  should be e
# we use this fact alongside the limit definition of the derivative to
    ↳ approximate e
for i in range(0, iterations):
    guessForE = (tooBig + tooSmall) / 2                                # like before,
    ↳ we start by averaging our upper and lower bounds
    slopeAtOne = -(guessForE - guessForE**(1 + dx))/(dx)              # we use the
    ↳ limit definition to approximate the slope; using a very small dx

    print(guessForE)                                                    # each
    ↳ iteration is printed to output

                                                                    # the slope
    ↳ should be equal to e, so we adjust our bounds based on that
    if slopeAtOne < guessForE:                                          # if our slope
    ↳ at  $x = 1$  is smaller than our estimate for e, then it's too small
        tooSmall = guessForE
    elif slopeAtOne > guessForE:                                        # if our slope
    ↳ at  $x = 1$  is larger than our estimate for e, then it's too big
        tooBig = guessForE
```

2.5

2.75

2.625

2.6875

2.71875  
 2.703125  
 2.7109375  
 2.71484375  
 2.716796875  
 2.7177734375  
 2.71826171875  
 2.718505859375  
 2.7183837890625  
 2.71832275390625  
 2.718292236328125  
 2.7182769775390625  
 2.7182846069335938  
 2.718280792236328  
 2.718282699584961  
 2.7182817459106445  
 2.7182822227478027  
 2.7182819843292236  
 2.718281865119934  
 2.7182818055152893  
 2.7182818353176117

### 1.3 Prime Generator

To prevent redundancy, this method only checks divisibility by prime factors. Also, when a prime is found, all factors of that number are removed from the list of numbers left to check. I know there's probably better algorithms, but it at least runs better than one which just checks divisibility for every combination of integers. On my laptop, it can generate 10,000 primes in a little over 3.5 seconds.

```

[10]: %%time

#n = int(input("How many primes?"))
n = 10000
upperLimit = 1000000

primes = [2]                                # we track the primes, starting with
↳ just 2

checked = [True, True]                      # we use an array of booleans to track
↳ what numbers have already been checked
for i in range(1, upperLimit//2):          # fill out boolean array, removing
↳ factors of 2
    checked.append(True)
    checked.append(False)

i = 3
while len(primes) < n:
  
```

```

        if checked[i] == False:           # if we don't know if the number is
        ↪prime
            for prime in primes:          # for every prime we already know
                if i % prime == 0:         # if evenly divisible
                    break                 # we're done
            else:
                primes.append(i)           # if after all that, the number is not
        ↪divisible, add to the list of primes
                j = 0
                while j < upperLimit:     # remove all factors of that number
        ↪from the list of possible primes
                    checked[j] = True     # since all factors of a prime are not
        ↪prime

                j += i
                checked[i] = True
            i += 1

print(primes)

```

```

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79, 83, 89, 97, 101, 103, 107, 109, 113, 127, 131, 137, 139, 149, 151, 157, 163,
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CPU times: user 3.61 s, sys: 945 µs, total: 3.62 s

Wall time: 3.61 s

```
[12]: %%time

# "dumb" algorithm for time comparison
# run at your own risk, it took my computer around 10 times as long to compute
↳ using this method

n = 10000
primes = [2]

i = 3
while len(primes) < n:
    for j in range(2,i):
        if i % j == 0:
            break
    else:
        primes.append(i)
    i += 1

print(primes)
```

[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, 1097, 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,

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CPU times: user 36.5 s, sys: 0 ns, total: 36.5 s  
Wall time: 36.5 s