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APMA 3100-003
Fall 2024

APMA 3100 Project 2, Stage 2

2. Design and use a Monte-Carlo simulation algorithm (see appendix below for a description of the Monte-Carlo simulation) You will simulate the calling process 500 times. You will develop an algorithm that generates a realization for W for each of 500 customers. Each realization will be independent from the others, as they will be created using different random numbers. A realization of the calling process should end when the customer answers the call or when four unsuccessful calls have been completed. The way of implementing the algorithm on a computer is up to you. due Sunday, Oct 20th at 11:59pm:

You should submit your 500 values of W, in numerical order, and a detailed description of how you produced these values.

$$W_C = (time\ spent\ calling\ customer\ C) = \sum_{i=1}^{n} (Dialing + Trial\ Outcome + Hang\ Up),\ n \leq 4$$

Our Monte-Carlo simulation algorithm follows the above formula to calculate the time spent calling each customer. An experiment is performed for each customer in the simulation. Each experiment involves calling the customer up to four times, with each call being considered a trial. The outcome of the trial is based on a pseudo-random number and the estimated probabilities of the outcomes.

In our simulation, the trial outcome is estimated with a discrete random variable, X, with three possible outcomes: the customer is busy with probability 0.2, unavailable with probability 0.3, or available with probability 0.5. If a customer is available, we use inverse transform sampling to estimate their time taken to answer the phone with a continuous, uniformly distributed random variable, Y, where the mean answer time is 12 seconds. The inverse CDF of Y is used to map the customer's value of "u" back onto the customer's value of "Y", where Y is the time taken to answer the phone.

The total time spent calling is tallied in a variable "W" for each customer. Each trial of a customer's experiment has a minimum of seven seconds where the operator Dialing takes six seconds and Hang Up takes one second. The values of W, u, and number of trials per experiment are available in Appendix A at the end of this PDF.

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```
# ------------------------------------------
Python 3.10

# 2a. Design a random number generator using the description shown in the appendix below. Report the values of
u51, u52, u53.

Random number generator function is below, our code continues after function declaration
# ------------------------------------------
def random_number_generator(seed, a, c, K, rand_integers):
    '''
    Take the given arguments and return a list of random numbers.
    a = multiplier
    c = increment
    K = modulus (bounds of random numbers)
    x0 = starting value (seed)
    rand_integers = number of random numbers to generate

    The algorithm is a linear congruential random number generator.
    '''
    u = [] * rand_integers        # Initialize array of random numbers 0-1 for customers with length
"rand_integers"
    xi = seed                     # xi = initial value of seed (makes generator pseudo-random)

    for i in range(rand_integers):
        xi = (a * xi + c) % K     # Generate the next value of xi using x(i-1)
        ui = xi / K               # Calculate the random number ui
        u.append(ui)

    return u                       # u is an array of all "u" for each customer
```

```
import math
# ------------------------------------------
# 2a. Design a random number generator using the description shown in the appendix below. Report the values of
u51, u52, u53.
# ------------------------------------------
```

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```
# Given inputs for the Project 2 linear congruential random number generator
a = 24693   # multiplier
c = 3517    # increment
K = 2**17   # modulus (bounds of random numbers)
x0 = 1000   # starting value (seed)

customers = 500                                    # Number of random numbers to generate
u = random_number_generator(x0, a, c, K, customers) # Call random number function to assign each customer an
initial probability

print(f"u51 = {u[50]}")                            # u51 = 0.5157089233398438
print(f"u52 = {u[51]}")                            # u52 = 0.427276611328125
print(f"u53 = {u[52]}\n")                          # u53 = 0.7681961059570312

# ---------------------------------------------
# 2b. Design an algorithm that uses a random variable to determine whether a customer is busy, unavailable, or
available.
# ---------------------------------------------

# X is a Random Variable where
# 1 = Busy
# 2 = Unavailable
# 3 = Available

customer_number = [0] * len(u)          # Initialize array of customer numbers for each customer
trial_count = [0] * len(u)              # Initialize array of trial counters for each customer
W = [0] * len(u)                        # Initialize array of time spent calling each customer

X = ([0, 1, 2, 3])                      # Dummy value of "0" needed because Python lists start at 0
pmf_X = ([0, 0.2, 0.3, 0.5])
cdf_X = ([0, 0.2, 0.5, 1])

for i in range(0, len(u)):              # Loop once for each customer
  customer_number[i] = i+1
  while (trial_count[i] < 4):           # Do not continue experiment for u[i] when trials >= 4
    trial_count[i] += 1                 # Increase trial counter before each call
```

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```
    W[i] += 6                          # Dialing, add 6 seconds

    if u[i] <= cdf_X[1]:
      W[i] += 3                        # Busy, add 3 seconds

    elif cdf_X[1] < u[i] <= cdf_X[2]:
      W[i] += 25                       # Unavailable, add 25 seconds

# ------------------------------------------
# 2c. Design an algorithm that uses a random variable to determine how much time it takes an available customer
to pick up the phone.
# As part of this, you will need to find the inverse of the cdf of X.
# ------------------------------------------
    elif cdf_X[2] < u[i] <= cdf_X[3]:
      Y = -12 * math.log(1-u[i])       # Inverse cdf of X~Exponential(λ) = (-1/λ) * log(1 - u), λ = 1/12
      if Y >= 25:
        W[i] += 25                     # Available, but Y >= 25 seconds to pick up (add 25 seconds)
      elif Y < 25:
        W[i] += Y                      # Available, picks up in Y < 25 seconds (add Y seconds)
        break

    W[i] += 1                          # Hang up, add 1 second
# ------------------------------------------
# 2d. Run your program to produce 500 realizations of W. That is - suppose there are 500 different customers.
# Use your algorithms to determine - for each of those customers, how long does the representative spend calling
that customer?
# Report those 500 values of W, in numerical order, in an appendix at the end of your report.
# ------------------------------------------

print("Customer #\tu_i\t\t\t\tTrial Count\tW (seconds)")
for i in range(0, len(u)):         # Loop once for each customer
  print(f"{customer_number[i]}\t\t{u[i]:.17f}\t\t{trial_count[i]}\t\t{W[i]}") # Print Customer #, u, Trial Count,
and W
  print()
```

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Appendix A

u51 = 0.5157089233398438
u52 = 0.427276611328125
u53 = 0.7681961059570312

Customer #	u_i	Trial #	W (seconds)
1	0.41947174072265625	4	128
2	0.04252624511718750	4	40
3	0.12740325927734375	4	40
4	0.99551391601562500	4	128
5	0.25196075439453125	4	128
6	0.69374084472656250	1	20.199883473595584
7	0.56951141357421875	1	16.114013614000008
8	0.97216796875000000	4	128
9	0.77048492431640625	1	23.6614387486302
10	0.61106872558593750	1	17.332231481154366
11	0.14687347412109375	4	40
12	0.77352905273437500	1	23.821663325148553
13	0.77973175048828125	1	24.154909913152952
14	0.94294738769531250	4	128
15	0.22667694091796875	4	128
16	0.36053466796875000	4	128
17	0.70938873291015625	1	20.82922508137403
18	0.96281433105468750	4	128
19	0.80110931396484375	1	25.379999059121115
20	0.81912231445312500	1	26.519210959336096
21	0.61414337158203125	1	17.42747288979749
22	0.06910705566406250	4	40
23	0.48735809326171875	4	128
24	0.36022949218750000	4	128
25	0.17368316650390625	4	40
26	0.78526306152343750	1	24.460098503550686
27	0.52761077880859375	1	14.99942414449902
28	0.31979370117187500	4	128
29	0.69269561767578125	1	20.158998590534782
30	0.75971984863281250	1	23.111396868464585
31	0.78905487060546875	1	24.67388675505466
32	0.15875244140625000	4	40
33	0.10086822509765625	4	40
34	0.76591491699218750	1	23.42484752537222
35	0.76387786865234375	1	23.32087322527223
36	0.46304321289062500	4	128
37	0.95288848876953125	4	128
38	0.70228576660156250	1	20.539454410670714
39	0.56926727294921875	1	16.10721004903329
40	0.94360351562500000	4	128
41	0.42844390869140625	4	128

42	0.59226989746093750	1	16.765798042309747
43	0.94741058349609375	4	128
44	0.43637084960937500	4	128
45	0.33222198486328125	4	128
46	0.58430480957031250	1	16.533636031214243
47	0.26549530029296875	4	128
48	0.90228271484375000	4	128
49	0.09391021728515625	4	40
50	0.95182800292968750	4	128
51	0.51570892333984375	1	14.70082985969606
52	0.42727661132812500	4	128
53	0.76819610595703125	1	23.542362588811145
54	0.09327697753906250	4	40
55	0.31523895263671875	4	128
56	0.22229003906250000	4	128
57	0.03476715087890625	4	40
58	0.53208923339843750	1	15.11373205078849
59	0.90627288818359375	4	128
60	0.62326049804687500	1	17.714415679438797
61	0.19831085205078125	4	40
62	0.91670227050781250	4	128
63	0.15599822998046875	4	40
64	0.09112548828125000	4	40
65	0.18851470947265625	4	40
66	0.02055358886718750	4	40
67	0.55660247802734375	1	15.759462846125993
68	0.21182250976562500	4	128
69	0.56006622314453125	1	15.853572846525951
70	0.74208068847656250	1	22.261301868107367
71	0.22527313232421875	4	128
72	0.69628906250000000	1	20.300146721042626
73	0.49265289306640625	4	128
74	0.10472106933593750	4	40
75	0.90419769287109375	4	128
76	0.38046264648437500	4	128
77	0.79096221923828125	1	24.782883289911382
78	0.25691223144531250	4	128
79	0.96056365966796875	4	128
80	0.22528076171875000	4	128
81	0.88468170166015625	4	128
82	0.47209167480468750	4	128
83	0.38655853271484375	4	128
84	0.31668090820312500	4	128
85	0.82849884033203125	1	27.157983005839796
86	0.14869689941406250	4	40
87	0.79936981201171875	1	25.27550311560694
88	0.86560058593750000	1	30.083270526679307

89	0.30210113525390625	4	128
90	0.81016540527343750	1	25.939225680535607
91	0.44118499755859375	4	128
92	0.20797729492187500	4	128
93	0.61017608642578125	1	17.30472174567313
94	0.10493469238281250	4	40
95	0.17919158935546875	4	40
96	0.80474853515625000	1	25.601603854676597
97	0.68241119384765625	1	19.76397354411057
98	0.80644226074218750	1	25.706153003108913
99	0.50557708740234375	1	14.452368355939138
100	0.24185180664062500	4	128
101	0.07349395751953125	4	40
102	0.81312561035156250	1	26.12782321125405
103	0.53752899169921875	1	15.254056904993952
104	0.23022460937500000	4	128
105	0.96311187744140625	4	128
106	0.14842224121093750	4	40
107	0.01723480224609375	4	40
108	0.60580444335937500	1	17.17089787400597
109	0.15595245361328125	4	40
110	0.96076965332031250	4	128
111	0.31188201904296875	4	128
112	0.32952880859375000	4	128
113	0.08170318603515625	4	40
114	0.52360534667968750	1	14.89810397583787
115	0.41365814208984375	4	128
116	0.48733520507812500	4	128
117	0.79505157470703125	1	25.019962985196173
118	0.23536682128906250	4	128
119	0.93975067138671875	4	128
120	0.29016113281250000	4	128
121	0.97568511962890625	4	128
122	0.61949157714843750	1	17.594963587838706
123	0.13234710693359375	4	40
124	0.07394409179687500	4	40
125	0.92829132080078125	4	128
126	0.32441711425781250	4	128
127	0.85863494873046875	1	29.47691661883987
128	0.29962158203125000	4	128
129	0.58255767822265625	1	16.483306747998324
130	0.12358093261718750	4	40
131	0.61080169677734375	1	17.323995460005698
132	0.55313110351562500	1	15.66588028612707
133	0.49317169189453125	4	128
134	0.91542053222656250	4	128
135	0.50603485107421875	1	14.463483756193558

136	0.54541015625000000	1	15.460316506587976
137	0.83982086181640625	1	27.977549716809317
138	0.72337341308593750	1	21.42104092715348
139	0.28652191162109375	4	128
140	0.11239624023437500	4	40
141	0.42719268798828125	4	128
142	0.69587707519531250	1	20.28387961675665
143	0.31945037841796875	4	128
144	0.21502685546875000	4	128
145	0.68497467041015625	1	19.86122678391597
146	0.10636901855468750	4	40
147	0.59700775146484375	1	16.906055419494198
148	0.93923950195312500	4	128
149	0.66785430908203125	1	19.22617893907625
150	0.35328674316406250	4	128
151	0.73638153076171875	1	21.99902896095175
152	0.49597167968750000	4	128
153	0.05551910400390625	4	40
154	0.96006774902343750	4	128
155	0.97975921630859375	4	128
156	0.22116088867187500	4	128
157	0.15265655517578125	4	40
158	0.57514953613281250	1	16.27221626034747
159	0.19432830810546875	4	40
160	0.57574462890625000	1	16.28903657686498
161	0.88895416259765625	4	128
162	0.97196960449218750	4	128
163	0.87227630615234375	1	30.694631881239424
164	0.14566040039062500	4	40
165	0.81909942626953125	1	26.517692580625116
166	0.04896545410156250	4	40
167	0.13079071044921875	4	40
168	0.64184570312500000	1	18.321496662916346
169	0.12277984619140625	4	40
170	0.82957458496093750	1	27.23349031701958
171	0.71205902099609375	1	20.939997046347
172	0.90023803710937500	4	128
173	0.60468292236328125	1	17.13680529480903
174	0.46223449707031250	4	128
175	0.98326873779296875	4	128
176	0.88177490234375000	4	128
177	0.69449615478515625	1	20.22951496586078
178	0.22038269042968750	4	128
179	0.93660736083984375	4	128
180	0.67239379882812500	1	19.39131597703558
181	0.44690704345703125	4	128
182	0.50245666503906250	1	14.37687144873394

183	0.18926239013671875	4	40
184	0.48303222656250000	4	128
185	0.54160308837890625	1	15.360238210866983
186	0.83189392089843750	1	27.39792090742872
187	0.98342132568359375	4	128
188	0.64962768554687500	1	18.58510721166441
189	0.28327178955078125	4	128
190	0.85713195800781250	1	29.35000629624283
191	0.18627166748046875	4	40
192	0.63311767578125000	1	18.032569497600868
193	0.60160064697265625	1	17.04360452640435
194	0.35160827636718750	4	128
195	0.29000091552734375	4	128
196	0.01943969726562500	4	40
197	0.05127716064453125	4	40
198	0.21376037597656250	4	128
199	0.41179656982421875	4	128
200	0.51953125000000000	1	14.79591706928574
201	0.81198883056640625	1	26.055046872434232
202	0.46702575683593750	4	128
203	0.29384613037109375	4	128
204	0.96932983398437500	4	128
205	0.68842315673828125	1	19.99331140006185
206	0.25984191894531250	4	128
207	0.30333709716796875	4	128
208	0.32977294921875000	4	128
209	0.11026763916015625	4	40
210	0.86564636230468750	1	30.087358416345822
211	0.43245697021484375	4	128
212	0.68679809570312500	1	19.930886817041582
213	0.13220977783203125	4	40
214	0.68287658691406250	1	19.781571181680622
215	0.29839324951171875	4	128
216	0.25134277343750000	4	128
217	0.43393707275390625	4	128
218	0.23497009277343750	4	128
219	0.14333343505859375	4	40
220	0.35934448242187500	4	128
221	0.32013702392578125	4	128
222	0.17036437988281250	4	40
223	0.83446502685546875	1	27.58287346074838
224	0.47174072265625000	4	128
225	0.72049713134765625	1	21.296912675100074
226	0.26249694824218750	4	128
227	0.86397552490234375	1	29.9390453458116
228	0.17446899414062500	4	40
229	0.18970489501953125	4	40

230	0.40980529785156250	4	128
231	0.34905242919921875	4	128
232	0.17846679687500000	4	40
233	0.90744781494140625	4	128
234	0.63572692871093750	1	18.118217961030883
235	0.03188323974609375	4	40
236	0.31967163085937500	4	128
237	0.67841339111328125	1	19.613860578937068
238	0.08869934082031250	4	40
239	0.27965545654296875	4	128
240	0.55902099609375000	1	15.825096178303218
241	0.93228912353515625	4	128
242	0.04216003417968750	4	40
243	0.08455657958984375	4	40
244	0.98245239257812500	4	128
245	0.72376251220703125	1	21.437931842796754
246	0.89454650878906250	4	128
247	0.06377410888671875	4	40
248	0.80090332031250000	1	25.3675769358993
249	0.73252105712890625	1	21.824573207801052
250	0.16929626464843750	4	40
251	0.45949554443359375	4	128
252	0.35031127929687500	4	128
253	0.26325225830078125	4	128
254	0.51484680175781250	1	14.679486783091402
255	0.13890838623046875	4	40
256	0.09161376953125000	4	40
257	0.24564361572265625	4	128
258	0.70463562011718750	1	20.63454598576295
259	0.59420013427734375	1	16.822742189830247
260	0.61074829101562500	1	17.322348933879216
261	0.23438262939453125	4	128
262	0.63710021972656250	1	18.163542842849132
263	0.94255828857421875	4	128
264	0.61865234375000000	1	17.56852603583655
265	0.40915679931640625	4	128
266	0.33567810058593750	4	128
267	0.92617034912109375	4	128
268	0.95126342773437500	4	128
269	0.57465362548828125	1	16.25821731765413
270	0.94880676269531250	4	128
271	0.91222381591796875	4	128
272	0.56951904296875000	1	16.114226287572663
273	0.16056060791015625	4	40
274	0.74992370605468750	1	22.63187078274357
275	0.89290618896484375	4	128
276	0.55935668945312500	1	15.834234605135526

277	0.22156524658203125	4	128
278	0.13746643066406250	4	40
279	0.48540496826171875	4	128
280	0.13171386718750000	4	40
281	0.43735504150390625	4	128
282	0.63487243652343750	1	18.090101969757708
283	0.93190765380859375	4	128
284	0.62252807617187500	1	17.691109044290037
285	0.11261749267578125	4	40
286	0.89057922363281250	4	128
287	0.09960174560546875	4	40
288	0.49273681640625000	4	128
289	0.17704010009765625	4	40
290	0.67802429199218750	1	19.599350127036818
291	0.48067474365234375	4	128
292	0.32827758789062500	4	128
293	0.18531036376953125	4	40
294	0.89564514160156250	4	128
295	0.19231414794921875	4	40
296	0.84008789062500000	1	27.9975711730091
297	0.31711578369140625	4	128
298	0.56687927246093750	1	16.04086528025158
299	0.97670745849609375	4	128
300	0.86410522460937500	1	29.950492836929726
301	0.37714385986328125	4	128
302	0.84016418457031250	1	28.003297730025437
303	0.20104217529296875	4	128
304	0.36126708984375000	4	128
305	0.79508209228515625	1	25.021749962601657
306	0.98893737792968750	4	128
307	0.85750579833984375	1	29.38144764246556
308	0.41751098632812500	4	128
309	0.62561798095703125	1	17.78974273910922
310	0.41163635253906250	4	128
311	0.56328582763671875	1	15.941716388409574
312	0.24377441406250000	4	128
313	0.54843902587890625	1	15.540538408271892
314	0.63169860839843750	1	17.986244125110304
315	0.56056976318359375	1	15.867315690297659
316	0.17599487304687500	4	40
317	0.86823272705078125	1	30.32061595410181
318	0.29756164550781250	4	128
319	0.71654510498046875	1	21.1284272271883
320	0.67510986328125000	1	19.491218335997722
321	0.51468658447265625	1	14.675524550054092
322	0.18266296386718750	4	40
323	0.52339935302734375	1	14.892916282119206

324	0.32705688476562500	4	128
325	0.04248809814453125	4	40
326	0.18544006347656250	4	40
327	0.09832000732421875	4	40
328	0.84277343750000000	1	28.200809287379883
329	0.63132476806640625	1	17.974069832939044
330	0.32933044433593750	4	128
331	0.18349456787109375	4	40
332	0.05819702148437500	4	40
333	0.08588409423828125	4	40
334	0.76277160644531250	1	23.264782992112607
335	0.14611053466796875	4	40
336	0.93426513671875000	4	128
337	0.83585357666015625	1	27.683957090956444
338	0.75920104980468750	1	23.085515102531907
339	0.97835540771484375	4	128
340	0.55691528320312500	1	15.767931514985904
341	0.93592071533203125	4	128
342	0.71705627441406250	1	21.1500870075809
343	0.29741668701171875	4	128
344	0.13708496093750000	4	40
345	0.06577301025390625	4	40
346	0.15977478027343750	4	40
347	0.34548187255859375	4	128
348	0.01071166992187500	4	40
349	0.53009796142578125	1	15.062772414813324
350	0.73579406738281250	1	21.972317185471233
351	0.98973846435546875	4	128
352	0.63873291015625000	1	18.21765279778211
353	0.25858306884765625	4	128
354	0.21855163574218750	4	128
355	0.72237396240234375	1	21.37776311240872
356	0.60708618164062500	1	17.209979794406912
357	0.80591583251953125	1	25.67356033216439
358	0.50648498535156250	1	14.474423949022768
359	0.66057586669921875	1	18.9660578751925
360	0.62670898437500000	1	17.824763529483377
361	0.35178375244140625	4	128
362	0.62303161621093750	1	17.707127492151294
363	0.54653167724609375	1	15.489958349572722
364	0.53353881835937500	1	15.150965688890938
365	0.70087432861328125	1	20.482697859047093
366	0.71662902832031250	1	21.131980629192864
367	0.74742889404296875	1	22.512749545921487
368	0.28851318359375000	4	128
369	0.28287506103515625	4	128
370	0.06071472167968750	4	40

371	0.25545501708984375	4	128
372	0.97756958007812500	4	128
373	0.15247344970703125	4	40
374	0.05372619628906250	4	40
375	0.68779754638671875	1	19.96924094189334
376	0.81164550781250000	1	26.033153938993536
377	0.98935699462890625	4	128
378	0.21910095214843750	4	128
379	0.28664398193359375	4	128
380	0.12667846679687500	4	40
381	0.09821319580078125	4	40
382	0.20527648925781250	4	128
383	0.91918182373046875	4	128
384	0.38360595703125000	4	128
385	0.40872955322265625	4	128
386	0.78569030761718750	1	24.48399779304937
387	0.07759857177734375	4	40
388	0.16836547851562500	4	40
389	0.47559356689453125	4	128
390	0.85877990722656250	1	29.489227967418326
391	0.87908172607421875	4	128
392	0.19189453125000000	4	40
393	0.47849273681640625	4	128
394	0.44798278808593750	4	128
395	0.06581878662109375	4	40
396	0.29013061523437500	4	128
397	0.22211456298828125	4	128
398	0.70173645019531250	1	20.51733345607324
399	0.00499725341796875	4	40
400	0.42401123046875000	4	128
401	0.13614654541015625	4	40
402	0.89347839355468750	4	128
403	0.68880462646484375	1	20.008012239848192
404	0.67947387695312500	1	19.65349798531685
405	0.27527618408203125	4	128
406	0.42164611816406250	4	128
407	0.73442840576171875	1	21.910449798040982
408	0.26745605468750000	4	128
409	0.31919097900390625	4	128
410	0.80967712402343750	1	25.90839962200099
411	0.38405609130859375	4	128
412	0.52389526367187500	1	14.905408975823164
413	0.57257843017578125	1	16.19981363803314
414	0.70600891113281250	1	20.690469864940376
415	0.50487518310546875	1	14.435344714281296
416	0.90972900390625000	4	128
417	0.96512603759765625	4	128

418	0.88407897949218750	4	128
419	0.58907318115234375	1	16.672081640058597
420	0.01089477539062500	4	40
421	0.05152130126953125	4	40
422	0.24232482910156250	4	128
423	0.75383758544921875	1	22.821164869789563
424	0.53833007812500000	1	15.274861176730635
425	0.01145172119140625	4	40
426	0.80418395996093750	1	25.566955580575968
427	0.74135589599609375	1	22.227627336726336
428	0.32797241210937500	4	128
429	0.64960479736328125	1	18.584323333426553
430	0.71809387207031250	1	21.19417371771267
431	0.91881561279296875	4	128
432	0.34075927734375000	4	128
433	0.39566802978515625	4	128
434	0.25749206542968750	4	128
435	0.27840423583984375	4	128
436	0.66262817382812500	1	19.038835381291594
437	0.30432891845703125	4	128
438	0.82081604003906250	1	26.632107499128523
439	0.43730926513671875	4	128
440	0.50451660156250000	1	14.426657165284695
441	0.05527496337890625	4	40
442	0.93150329589843750	4	128
443	0.63771820068359375	1	18.18399502610421
444	0.20236206054687500	4	128
445	0.95319366455078125	4	128
446	0.23799133300781250	4	128
447	0.74681854248046875	1	22.48378588726854
448	0.21710205078125000	4	128
449	0.92777252197265625	4	128
450	0.51371765136718750	1	14.651590314132022
451	0.25679779052734375	4	128
452	0.13467407226562500	4	40
453	0.53369903564453125	1	15.155088084828714
454	0.65711975097656250	1	18.84448825184631
455	0.28484344482421875	4	128
456	0.66601562500000000	1	19.159932822442173
457	0.95066070556640625	4	128
458	0.69163513183593750	1	20.117658722890518
459	0.57314300537109375	1	16.215674748476495
460	0.64706420898437500	1	18.49762960480368
461	0.98334503173828125	4	128
462	0.76570129394531250	1	23.413901473010426
463	0.48888397216796875	4	128
464	0.03875732421875000	4	40

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465	0.06143951416015625	4	40
466	0.15275573730468750	4	40
467	0.02425384521484375	4	40
468	0.92703247070312500	4	128
469	0.23963165283203125	4	128
470	0.25123596191406250	4	128
471	0.79644012451171875	1	25.10154106719054
472	0.52282714843750000	1	14.878517777836011
473	0.19760894775390625	4	40
474	0.58457946777343750	1	16.541567293895564
475	0.04763031005859375	4	40
476	0.16207885742187500	4	40
477	0.24005889892578125	4	128
478	0.80122375488281250	1	25.38690579913873
479	0.64501190185546875	1	18.4280521970661
480	0.30572509765625000	4	128
481	0.29666900634765625	4	128
482	0.67460632324218750	1	19.472634199190942
483	0.08077239990234375	4	40
484	0.53970336914062500	1	15.310609771571128
485	0.92212677001953125	4	128
486	0.10316467285156250	4	40
487	0.47209930419921875	4	128
488	0.57495117187500000	1	16.266614723413856
489	0.29611968994140625	4	128
490	0.11033630371093750	4	40
491	0.56118011474609375	1	15.883994811074484
492	0.24740600585937500	4	128
493	0.22333526611328125	4	128
494	0.84455871582031250	1	28.337846548428704
495	0.71520233154296875	1	21.071715432903954
496	0.51800537109375000	1	14.75786770009984
497	0.13346099853515625	4	40
498	0.57926940917968750	1	16.38915092319487
499	0.92635345458984375	4	128
500	0.47268676757812500	4	128