Assignment

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Problem 1

Generate 100 random from a Bivariate Generalized exponential, Bivariate Weibull distribution.

Bivariate Generalized Exponential

To generate Random Variables From Bivariate Generalized Exponential Distribution We can use following Steps

1. Generate $U_1 \sim GE(\alpha_1, \lambda)$,$U_2 \sim GE(\alpha_2, \lambda)$,$U_3 \sim GE(\alpha_3, \lambda)$
2. Assign $X_1 = max\{U_1, U_3\}$ and $X_2 = max\{U_2, U_3\}$
3. Return (X_1, X_2)

Now to Generate Random Numbers from Generalized Exponential Distribution we can use Inverse Transform Method as follows

$$\textit{CDF of Generealized Exponential is given by}$$
$$F(x, \alpha, \lambda) = (1 - e^{-\lambda x})^{\alpha}$$
$$U = (1 - e^{-\lambda x})^{\alpha}$$
$$x = -\frac{1}{\lambda} ln\left(1 - U^{\frac{1}{\alpha}}\right)$$

Creating a function to generate Random Variable from Generalized Exponential

```
rge <- function(alpha , lambda){
  u = runif(1)
  x = -log(1 - u^(1/alpha))/lambda
  return(x)
}
```

Creating a function to generate Random Variable from Bivariate Generalized Exponential

```
rbge <- function(alpha1,alpha2,alpha3,lambda){
  u1 = rge(alpha1,lambda)
  u2 = rge(alpha2,lambda)
  u3 = rge(alpha3,lambda)
  x1 = max(u1,u3)
  x2 = max(u2,u3)
  x = c(x1,x2)
  return(x)
}
```

Code

```
a = c()
for(i in 1:100){
  x = rbge(20,24,32,0.1)
  a = rbind(a,x)

}
print(a)
```

```
##       [,1]      [,2]
## x 32.98167  38.28575
## x 50.90362  51.30821
## x 69.21246  35.88713
## x 30.77216  66.00130
## x 44.74599  44.74599
## x 32.86428  30.96410
## x 34.85648  35.55930
## x 39.72127  28.95534
## x 44.11453  44.11453
## x 30.38555  27.84260
## x 44.35035  38.35938
## x 57.96818  57.96818
## x 49.90315  43.73717
## x 49.50310  49.50310
## x 36.84536  36.84536
## x 37.15952  36.81199
## x 25.05961  48.99083
## x 45.83839  45.83839
## x 63.31067  50.87229
## x 33.64776  33.64776
## x 32.35209  64.49875
## x 32.23705  32.23705
## x 34.61133  28.99005
## x 33.13287  33.13287
## x 48.76130  48.76130
## x 45.58545  41.37105
## x 35.09156  62.60688
## x 46.89798  46.89798
## x 42.77921  42.77921
## x 44.69805  76.04416
## x 48.57341  31.83144
## x 53.40027  27.56855
## x 40.26329  40.26329
## x 65.93334  66.20889
## x 78.88973  78.88973
## x 45.12570  62.62375
## x 47.16711  50.81783
## x 44.07527  44.07527
## x 43.16186  43.16186
## x 55.43809  44.28747
## x 48.17708  37.72436
## x 46.59593  46.59593
## x 43.18800  43.18800
```

```
## x 27.27219  34.09563
## x 35.98047  35.95372
## x 32.08790  32.08790
## x 27.76454  35.57212
## x 36.78308  42.54361
## x 55.75893  30.29091
## x 42.97378  42.97378
## x 33.36168  35.83629
## x 48.10890  65.37916
## x 51.30314  51.30314
## x 34.17851  32.59459
## x 37.47508  30.49478
## x 47.64433  47.64433
## x 44.63731  33.22850
## x 47.09776  26.36653
## x 35.75864  65.18044
## x 42.71531  42.71531
## x 38.45816  38.45816
## x 33.72060 108.89004
## x 40.42622  40.42622
## x 33.29870  55.38058
## x 31.41928  31.35238
## x 35.97464  43.49078
## x 61.08670  61.08670
## x 72.92120  72.92120
## x 36.71710  36.71710
## x 82.40466  82.40466
## x 64.07384  43.20974
## x 50.87984  44.64367
## x 45.41981  46.11304
## x 36.82850  70.23372
## x 38.34960  78.05238
## x 29.56275  50.17854
## x 36.52012  36.93764
## x 47.11547  53.72321
## x 56.68117  41.55774
## x 38.32497  49.85134
## x 48.49802  64.73851
## x 42.88559  42.88559
## x 38.04049  37.56887
## x 34.87315  39.12049
## x 32.55250  30.00176
## x 48.62505  33.10007
## x 46.95719  46.95719
## x 26.94416  28.58011
## x 54.59511  54.59511
## x 79.35683  35.62576
## x 40.90355  46.56381
## x 34.08399  54.58121
## x 43.12482  43.12482
## x 51.24623  45.39755
## x 39.64014  39.64014
## x 40.87362  38.83317
## x 45.80782  45.80782
```

```
## x 37.14929  37.14929
## x 35.09541  41.19232
## x 55.71332  55.71332
```

Bivariate Weibull Distribution

To generate Random Variables From Bivariate Weibull Distribution We can use following Steps

1. Generate $U_1 \sim WE(\alpha, \lambda_1)$,$U_2 \sim WE(\alpha, \lambda_2)$,$U_3 \sim WE(\alpha, \lambda_3)$
2. Assign $X_1 = min\{U_1, U_2\}$ and $X_2 = min\{U_1, U_3\}$
3. Return (X_1, X_2)

Code

```
rbwd <- function(n,alpha,lambda1,lambda2,lambda3){
  #u1 = rweibull(n,alpha,1/lambda1)
  #u2 = rweibull(n,alpha,1/lambda2)
  #u3 = rweibull(n,alpha,1/lambda3)
  u1 = (-log(1-runif(n))/lambda1)^(1/alpha)
  u2 = (-log(1-runif(n))/lambda2)^(1/alpha)
  u3 = (-log(1-runif(n))/lambda3)^(1/alpha)
  x1 = pmin(u1,u2)
  x2 = pmin(u1,u3)
  x = cbind(x1,x2)
  return(x)
}
```

```
b = rbwd(100,10,22,3,7)
print(b)
```

```
##               x1        x2
##   [1,] 0.4376432 0.4376432
##   [2,] 0.7683868 0.7435689
##   [3,] 0.7580092 0.6828425
##   [4,] 0.6168975 0.6168975
##   [5,] 0.6346159 0.6346159
##   [6,] 0.7683515 0.7683515
##   [7,] 0.7848283 0.5333769
##   [8,] 0.7998586 0.8568250
##   [9,] 0.5049943 0.5049943
##  [10,] 0.6813877 0.6813877
##  [11,] 0.7034721 0.7034721
##  [12,] 0.7320021 0.7320021
##  [13,] 0.7388841 0.7388841
##  [14,] 0.5813444 0.6657414
##  [15,] 0.5827276 0.5827276
##  [16,] 0.7195141 0.7195141
##  [17,] 0.6149591 0.6149591
##  [18,] 0.7579327 0.7579327
##  [19,] 0.6286172 0.6286172
##  [20,] 0.7116264 0.7725224
##  [21,] 0.7007504 0.6302454
##  [22,] 0.5941464 0.5941464
```

```
##  [23,] 0.7066732 0.4106476
##  [24,] 0.7591608 0.7530800
##  [25,] 0.7011768 0.7011768
##  [26,] 0.6943094 0.6943094
##  [27,] 0.7511172 0.7511172
##  [28,] 0.6737623 0.6737623
##  [29,] 0.7287660 0.7438368
##  [30,] 0.7241101 0.7241101
##  [31,] 0.7419701 0.7419701
##  [32,] 0.6884241 0.6884241
##  [33,] 0.6232324 0.6232324
##  [34,] 0.6742368 0.6742368
##  [35,] 0.8013463 0.8013463
##  [36,] 0.7736404 0.7202582
##  [37,] 0.7529167 0.7529167
##  [38,] 0.5994939 0.5994939
##  [39,] 0.5960961 0.5960961
##  [40,] 0.6385933 0.6385933
##  [41,] 0.7116130 0.7116130
##  [42,] 0.5792930 0.5792930
##  [43,] 0.8271750 0.7944939
##  [44,] 0.5038562 0.5038562
##  [45,] 0.6399992 0.6399992
##  [46,] 0.6420831 0.6420831
##  [47,] 0.5994543 0.5994543
##  [48,] 0.6373942 0.6373942
##  [49,] 0.6770474 0.6770474
##  [50,] 0.6578934 0.6578934
##  [51,] 0.6231399 0.6231399
##  [52,] 0.7560412 0.7560412
##  [53,] 0.7970370 0.7970370
##  [54,] 0.6548575 0.8154473
##  [55,] 0.7240459 0.7240459
##  [56,] 0.7438969 0.7438969
##  [57,] 0.6132058 0.6132058
##  [58,] 0.7160790 0.7160790
##  [59,] 0.7145191 0.7145191
##  [60,] 0.7335338 0.7335338
##  [61,] 0.7297332 0.7297332
##  [62,] 0.6572135 0.6572135
##  [63,] 0.7506818 0.7506818
##  [64,] 0.7105426 0.6863287
##  [65,] 0.7024244 0.7707047
##  [66,] 0.7090964 0.7090964
##  [67,] 0.6593639 0.6593639
##  [68,] 0.6838953 0.6838953
##  [69,] 0.4944332 0.4944332
##  [70,] 0.7958726 0.7958726
##  [71,] 0.6779947 0.6779947
##  [72,] 0.6256031 0.7912275
##  [73,] 0.6797429 0.6797429
##  [74,] 0.7178073 0.7178073
##  [75,] 0.6309862 0.6309862
##  [76,] 0.6797688 0.6650911
```

```
##  [77,] 0.6907832 0.6907832
##  [78,] 0.5211621 0.5211621
##  [79,] 0.7328634 0.7107630
##  [80,] 0.6173766 0.6173766
##  [81,] 0.5996414 0.5996414
##  [82,] 0.8052665 0.8052665
##  [83,] 0.5968458 0.5968458
##  [84,] 0.6059696 0.6059696
##  [85,] 0.6214558 0.6214558
##  [86,] 0.6232360 0.6232360
##  [87,] 0.7251119 0.7251119
##  [88,] 0.7214239 0.7214239
##  [89,] 0.7576003 0.7543790
##  [90,] 0.7375451 0.7375451
##  [91,] 0.5135439 0.5135439
##  [92,] 0.6744597 0.6808289
##  [93,] 0.7274869 0.7274869
##  [94,] 0.6151761 0.6151761
##  [95,] 0.7769037 0.5140910
##  [96,] 0.7425012 0.7425012
##  [97,] 0.6778900 0.5321962
##  [98,] 0.6644253 0.6644253
##  [99,] 0.7499110 0.7499110
## [100,] 0.6966879 0.6966879
```

Problem 2

Generate 100 random from an absolutely continuous bivariate Generalized exponential, absolutely continuous Bivariate Weibull distribution

Absolutely Continuous Bivariate Generalized Exponential

To Get Random Number with absolutely continuous bivariate Generalized exponential we can use the same procedure as we have done in Problem 1. We just have to take care of singular points so we will reject the sample when $X_1 = X_2$

Code

```
c = c()
while(length(c)<200){
  x = rbge(1,2,3,4)
  if(x[1] == x[2]){
    next
  }
  c = rbind(c,x)
}
print(c)
```

```
##         [,1]      [,2]
## x 0.52331296 0.4896304
## x 0.77477916 0.8553549
## x 0.24920121 0.4316822
## x 0.27774605 0.3679842
## x 0.09057178 0.3389646
```

```
## x 0.48417283 0.7214691
## x 0.28335816 0.6838526
## x 0.43024667 0.6295717
## x 0.52444719 0.5733910
## x 1.03150534 0.7887037
## x 0.47287342 0.6019730
## x 0.22105280 0.1740717
## x 0.12090370 0.8841873
## x 0.76467017 0.5927732
## x 0.55598486 0.5090078
## x 0.27908759 0.2530989
## x 0.47689990 1.1105562
## x 0.24618189 0.4150565
## x 0.19765002 1.2813366
## x 0.61325402 0.2202113
## x 0.48236704 0.2142941
## x 0.64692456 0.4932252
## x 0.37447688 1.5141102
## x 0.34685416 0.2510132
## x 0.42943685 0.3621314
## x 0.30518875 0.6119012
## x 0.13362094 0.1484226
## x 0.53240594 0.3478859
## x 0.07586211 0.3474518
## x 0.13559948 0.2956995
## x 1.15636703 0.2677929
## x 0.21157397 0.7762685
## x 0.37535201 0.2456984
## x 0.48454519 0.7885115
## x 0.22467831 0.4460881
## x 0.70972116 1.1615541
## x 0.64908383 0.3776358
## x 0.13846001 0.1838414
## x 0.26897790 0.2991643
## x 0.72034905 0.6747098
## x 0.73947849 0.1367004
## x 0.36594795 0.3256849
## x 0.43579579 0.4788031
## x 0.49686939 0.7309911
## x 0.44525361 0.5338485
## x 0.44926099 0.6951170
## x 0.33313032 0.8747752
## x 0.44406750 0.5660730
## x 0.50736720 0.3582661
## x 0.38802957 0.4071692
## x 0.32357418 0.3808982
## x 0.18550558 0.6532238
## x 0.44657081 0.2139014
## x 0.27305533 0.4876360
## x 0.28847711 0.2298697
## x 0.34605716 0.5503920
## x 0.41296778 0.4564674
## x 0.69643012 0.3244819
## x 0.80761023 0.3138947
```

```
## x 0.47793877 0.4324659
## x 0.13200287 0.1149219
## x 0.24992324 0.7429885
## x 1.02324001 0.2188300
## x 0.29151285 1.2074265
## x 0.47591818 0.5676950
## x 0.15229243 0.5025883
## x 0.32284322 0.3549467
## x 0.82479677 1.6775123
## x 0.20869499 0.3123936
## x 0.43252102 0.6892547
## x 0.69697074 0.3510380
## x 0.40219059 0.5030779
## x 0.22617401 0.6275296
## x 0.71358617 0.5362875
## x 0.80371069 0.7245815
## x 0.29207499 0.6925190
## x 0.36238450 0.5841089
## x 0.72404001 0.3877413
## x 0.30115375 0.2884593
## x 0.15937137 0.3321843
## x 0.66234178 0.4339677
## x 0.50576058 0.3921808
## x 0.15143163 0.4503879
## x 0.19649532 0.3689760
## x 0.07113336 0.1386867
## x 0.16845684 0.1996286
## x 0.54596817 1.5002297
## x 0.62469369 0.2753200
## x 0.22647475 0.4259819
## x 0.27363840 0.2784844
## x 0.06067439 0.4523126
## x 0.14180286 0.3090951
## x 0.21673187 0.9564048
## x 0.85771525 0.8875275
## x 0.70104101 0.7236980
## x 0.10591453 0.1258520
## x 0.71947941 0.3373176
## x 0.28119655 0.3146871
## x 0.36099244 0.3644119
## x 0.32046737 0.4866876
```

Absolutely Continuous Bivariate Weibull distribution

Similarly as above we can write

```
d = c()
while(length(d)<200){
  x = rbwd(1,1,2,3,4)
  if(x[1] == x[2]){
    next
  }
  d = rbind(d,x)
}
print(d)
```

```
##                 x1          x2
##   [1,] 0.258290415 0.021660739
##   [2,] 0.206460744 0.048642293
##   [3,] 0.006894769 0.054326843
##   [4,] 0.079892589 0.122466582
##   [5,] 0.160722733 0.520115132
##   [6,] 0.336406017 0.049621636
##   [7,] 0.515837756 0.087877238
##   [8,] 0.486375358 0.198934681
##   [9,] 0.369776379 0.668619929
##  [10,] 0.140754605 0.124989917
##  [11,] 0.177093389 0.121225979
##  [12,] 0.296024350 0.087797239
##  [13,] 0.312592836 0.039389532
##  [14,] 0.553326001 0.171610154
##  [15,] 1.057984320 0.095461673
##  [16,] 0.011207560 0.030626680
##  [17,] 0.333017242 0.029200470
##  [18,] 0.302978167 0.091572250
##  [19,] 0.525073689 0.333080117
##  [20,] 0.123376890 0.156852279
##  [21,] 0.005662339 0.343342640
##  [22,] 0.128349997 0.197144041
##  [23,] 0.446115967 0.288074632
##  [24,] 0.164576864 0.133737647
##  [25,] 0.194593186 0.516076360
##  [26,] 0.771319743 0.459670273
##  [27,] 0.096000546 0.525408858
##  [28,] 0.065155146 0.098722273
##  [29,] 0.545550780 0.028472010
##  [30,] 0.163207392 0.092637534
##  [31,] 0.258210520 0.327617144
##  [32,] 0.015075107 0.310750968
##  [33,] 0.041781232 0.291257351
##  [34,] 0.036869919 0.294047265
##  [35,] 0.022507748 0.067063790
##  [36,] 0.034403454 0.008316772
##  [37,] 0.553037369 0.101810353
##  [38,] 0.333412085 0.001306942
##  [39,] 0.002733268 0.067859324
##  [40,] 0.295960139 0.081079222
##  [41,] 0.048407514 0.218468898
##  [42,] 0.110651661 0.139692052
##  [43,] 0.432234578 0.335533302
##  [44,] 0.504211791 0.611426209
##  [45,] 0.072681915 0.273342103
##  [46,] 0.148101280 0.396687222
##  [47,] 0.092610080 0.015126410
##  [48,] 0.221743826 0.157050793
##  [49,] 0.111932312 0.080961355
##  [50,] 0.154538096 0.116095997
##  [51,] 0.744290497 0.026804982
```

```
##  [52,] 0.457439086 0.070128385
##  [53,] 0.105514253 0.093235548
##  [54,] 0.156568834 0.430395668
##  [55,] 0.404500576 0.006868035
##  [56,] 0.146800951 0.149339694
##  [57,] 0.155939675 0.115763915
##  [58,] 0.169189945 0.154498792
##  [59,] 0.135722903 0.128973373
##  [60,] 0.159090112 0.002116385
##  [61,] 0.110547357 0.241721457
##  [62,] 0.153169785 0.097117484
##  [63,] 0.078066414 0.148543797
##  [64,] 0.249655939 0.251920348
##  [65,] 0.279557527 0.103910144
##  [66,] 0.286824958 0.055153575
##  [67,] 0.117526301 0.457856216
##  [68,] 0.186271484 0.042445537
##  [69,] 0.087575774 0.304179454
##  [70,] 0.143536774 0.404403695
##  [71,] 0.056315369 0.094044390
##  [72,] 0.135747188 0.208927205
##  [73,] 0.385147818 0.111668267
##  [74,] 0.172266301 0.031940945
##  [75,] 0.524794760 0.069575600
##  [76,] 0.161880754 0.137491898
##  [77,] 0.156482643 0.038289395
##  [78,] 0.053920200 0.033856051
##  [79,] 0.411810287 0.171391353
##  [80,] 0.066407708 0.095905769
##  [81,] 0.145143012 0.012685676
##  [82,] 0.329810230 0.067382862
##  [83,] 0.207322419 0.058855379
##  [84,] 0.150402570 0.172670780
##  [85,] 0.173251902 0.505122873
##  [86,] 0.375654870 0.060933582
##  [87,] 0.084888622 0.256407428
##  [88,] 0.110241856 0.049709887
##  [89,] 0.042172031 0.177222836
##  [90,] 0.115822372 0.050404288
##  [91,] 0.107161822 0.138773458
##  [92,] 0.026526026 0.001404156
##  [93,] 0.288105333 0.026543883
##  [94,] 0.191404751 0.302837307
##  [95,] 0.086986002 0.412728463
##  [96,] 0.012758007 0.399465386
##  [97,] 0.188138288 0.007132840
##  [98,] 0.014919704 0.530861644
##  [99,] 0.345279610 0.067674348
## [100,] 0.359263131 0.133176376
```