major.r

denis

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#!/usr/bin/r  
  
# We use the notation a ∗j to correspond to the j th column of the matrix A  
# and use a i∗ to represent the (column) vector that corresponds to the i th   
# row.  
# The ﬁrst row is the 1 st (ﬁrst) row, and the ﬁrst column is the 1 st (ﬁrst)  
# column. (Again, we remark that computer entities used in some systems to  
# represent matrices and to store elements of matrices as computer data some-  
# times index the elements beginning with 0. Furthermore, some systems use the  
# ﬁrst index to represent the column and the second index to indicate the row.  
# We are not speaking here of the storage order — “row major” versus “column  
# major” — we address that later, in Chapter 11. Rather, we are speaking of the  
# mechanism of referring to the abstract entities. In image processing, for   
# exam-  
# ple, it is common practice to use the ﬁrst index to represent the column and  
# the second index to represent the row. In the software package PV-Wave, for  
# example, there are two diﬀerent kinds of two-dimensional objects: “arrays”,   
# in  
# which the indexing is done as in image processing, and “matrices”, in which  
# the indexing is done as we have described.)  
n = 1  
j <- rnorm(100)  
j

## [1] 0.513459373 1.916353573 -1.154913329 -1.563167489 -0.473966236  
## [6] 1.061764038 -1.078334860 -1.470643744 0.317525969 -0.013467125  
## [11] -0.184644678 0.504428222 0.554891246 0.397539081 0.828520424  
## [16] 0.428634566 1.099303284 0.615760633 1.108503351 -0.521090671  
## [21] 1.087127431 0.209280420 -0.355580915 0.302218023 -0.099240900  
## [26] 0.712158354 -0.553545313 -0.329031991 1.364701147 0.606365185  
## [31] 0.427187054 -0.542914942 1.242882890 1.923067136 1.319664538  
## [36] 1.734774868 1.695578567 1.845103698 -0.665289763 0.168540682  
## [41] 0.114689061 0.552540189 0.005622423 0.047026991 -0.690195379  
## [46] -0.334334589 -0.167741938 0.274514848 -2.664102352 -0.433543610  
## [51] 0.453230387 0.136159172 -1.849157659 -0.536334988 -0.075333191  
## [56] 0.580894664 0.439835190 -0.653318013 0.249495789 1.024596403  
## [61] 0.149858235 -0.941656322 0.083676308 0.403166027 1.594858613  
## [66] 0.865826732 -0.135826104 -0.958005388 -0.615962778 1.089930624  
## [71] 0.821705005 -1.755113571 1.420767249 -1.138444516 0.031234510  
## [76] -2.563313591 0.857659214 1.206280513 0.346850927 -0.838931017  
## [81] 0.624207834 -0.359358760 -0.068202469 0.756722864 -1.664996556  
## [86] 0.340005202 -0.701590971 0.119618473 -0.134378262 0.086688432  
## [91] 0.876333243 1.125799428 -0.596112336 -0.318446075 -0.243821461  
## [96] -0.480176401 -1.258630966 -0.352604754 -0.602947372 -0.398181093

jh <- c(100 \* 10 + sin(2))  
jh

## [1] 1000.909

a <- c(111, 1112, 111, 1112)  
a

## [1] 111 1112 111 1112

# We also write the matrix A above as  
a <- rnorm(1110)  
a

## [1] 0.1992740687 1.1031479721 0.4400549175 0.5715046990 -1.3199755220  
## [6] 1.5756413991 -0.1576403251 -2.1950963845 -0.9185996204 -0.6747566260  
## [11] -0.6796626399 -1.1427551659 0.7070369018 -0.3204232617 0.4223483626  
## [16] 1.4971268995 0.7176519360 1.1654609829 -0.0073939184 -0.6001975519  
## [21] 1.5641453063 0.0775014664 -1.6339810701 -0.8084488163 1.2323994900  
## [26] 0.3315719949 -0.3728143168 -0.2170487486 0.5616044329 -0.6964363484  
## [31] -0.6181568282 -1.3831683126 1.2030212387 -0.3056304070 -1.3605070553  
## [36] -0.9423341680 1.4008430371 0.3376552232 0.0845937445 -0.2025962023  
## [41] -0.5747335794 0.8622152296 -0.0394137003 -0.0406165397 0.8636600589  
## [46] 0.6053405680 -0.5368847626 0.3689696831 0.8469908067 1.1339031985  
## [51] 1.3570942345 -2.7074503091 0.1375289098 -1.6131823120 1.3405254363  
## [56] -1.3990794723 -0.1257456927 -0.9208827702 -1.1951912414 -0.0563039011  
## [61] 1.5744182767 0.2089279879 -0.2573802041 -1.4102182718 -0.7647492453  
## [66] -0.9645508489 -1.7695400002 0.6021466565 0.0198169482 -0.6086816370  
## [71] -0.4319832850 0.3149292516 -0.0446669870 -0.2033412189 -0.6511484773  
## [76] 1.3994818672 -0.0026761943 -1.0318140588 0.4493164792 0.0213385806  
## [81] 0.9702526396 -0.4260420027 0.0654361398 -1.2472518366 -1.1433230906  
## [86] -1.1288244159 -0.2630907806 -0.2333170987 1.7489197374 1.0984182533  
## [91] -0.6159465206 -0.1755915268 0.0566065960 -0.2564774598 -0.3934734599  
## [96] -0.5469834928 0.1028997932 -0.0587559458 0.7648569324 -1.0632609252  
## [101] 0.0818294854 0.1909809791 -0.8392475691 0.1966370936 -1.9478973581  
## [106] 1.3412500669 -0.0805183395 0.8926756540 0.4435952195 -0.4749359403  
## [111] 1.0724488482 -0.0987160538 -1.9116528816 1.6644367925 0.9764633632  
## [116] 0.2563383381 -0.0839282471 -0.2649941653 1.2006261139 1.1260575395  
## [121] -1.4614673035 2.2854268197 -0.7838739262 -0.7363068530 -0.5414678829  
## [126] 0.6985110270 -0.7903663196 -0.0353087992 -0.1183879748 0.7130602684  
## [131] 0.6239860476 -2.6674261237 -0.3907404766 0.5802405216 -0.5891665240  
## [136] 0.0618198868 0.7843479079 -1.9764348741 1.2357394620 -0.6449419740  
## [141] -0.5536087361 0.9427577807 -0.4130599658 -1.8224682553 -1.3685051835  
## [146] -0.5908226644 1.9488147314 -1.1704613322 1.0785760444 -0.3521000070  
## [151] 0.2896709451 -0.4227009578 -1.6423790778 0.0418567663 -0.8526235475  
## [156] -0.6077738960 0.4049142291 -0.7442304366 0.8130760174 -0.7443272270  
## [161] 0.0582660804 0.3154474351 0.7058903064 -0.0606413210 1.4654657694  
## [166] 1.1529910080 0.9767076648 -0.9343373874 -0.9271343503 -0.5725557675  
## [171] 1.3333217315 -0.2709980536 0.8100788006 -1.1570475653 -0.0735254849  
## [176] -1.1029623557 0.2139824363 0.5220191719 -1.5720071225 1.4683287634  
## [181] 0.1272609124 -0.3970770062 -0.8193402512 0.0149641719 -0.1041616415  
## [186] -0.6519516594 -0.6072606642 1.1925636523 1.0258544116 -1.3638298221  
## [191] -0.0962038870 0.3896399616 -0.5507598188 -0.3502751465 0.7217711634  
## [196] -0.3643972434 -0.1867249297 0.5490439608 0.5896951279 -0.6118150189  
## [201] -2.9547925402 -2.3338328778 -2.0925673839 -1.9050322242 -1.2312929260  
## [206] 1.5574970603 0.5206575178 0.8046031803 -0.0478759502 -1.4027564217  
## [211] -2.1418739245 -0.0499771136 1.4845830507 0.1735278672 -0.6044764330  
## [216] 1.1395887268 -0.0533119559 -0.5714269101 0.6241206467 -1.5035285180  
## [221] -0.6991121368 1.0454935849 0.0642456117 -0.1171837494 -1.7101442876  
## [226] 0.7109954540 -1.2190654688 0.3557308027 1.4355022576 -0.2912630599  
## [231] -0.7426320504 0.0431133318 0.7326314951 -0.1861243682 -0.4969439598  
## [236] 0.9921069479 -0.4032362345 1.2438568387 -0.1605339928 -1.8475072222  
## [241] 2.0790391210 -0.7084878689 -0.1055797609 -1.5529260020 2.2886597077  
## [246] 2.2039924596 -1.5397940800 0.0909668963 1.0352984203 1.6030139723  
## [251] 0.6096524435 1.5886993903 1.1628922882 0.7757201658 -0.5876741730  
## [256] -0.0553105405 1.4896527302 -0.2938401191 -1.7454420559 0.7242481043  
## [261] 0.7695799228 -0.1330847168 1.2076746750 -0.8011270001 1.0549275923  
## [266] 0.6650370464 1.5964472755 -0.7754712365 0.6825548540 1.1754065392  
## [271] -0.0453586396 -0.0586698656 -0.0867977310 -0.0368872232 0.4449615287  
## [276] -0.8285117402 0.1397982642 -0.2565912361 1.1327468063 0.5699973551  
## [281] -0.7946753176 0.4409777380 -1.6570435994 0.2012862295 -0.1990937250  
## [286] 0.2529469146 -1.5688394824 -1.0132020329 -1.5104681823 -0.1838718080  
## [291] 1.3171527589 -0.3057502740 1.0832012831 0.9537460710 -0.7822993622  
## [296] -0.7685070643 -1.3972872304 0.8890678588 -0.2348425753 2.2032670779  
## [301] 0.0887067689 1.1631186824 0.8956616188 -1.2247373132 -0.6712108595  
## [306] -0.2654747623 -1.6297289679 -0.4037263285 -0.9568131323 1.5406815545  
## [311] -0.2268061411 0.5140066182 0.7442773632 -0.8809685459 -0.1908185589  
## [316] -0.4374457274 -1.8886579387 -0.1968109466 -0.4510052470 1.4913934257  
## [321] 0.8899220304 -0.2140180591 -1.2452043947 0.5687758343 -0.4144240738  
## [326] -0.6343620993 -0.0786664103 0.7557647590 -1.0702569756 1.5564231030  
## [331] -1.2264581131 -0.0439195376 1.8823047030 -0.0584115681 -0.1906773910  
## [336] 1.9294425885 0.6584479198 0.5973014719 -0.1756169437 -0.0504644244  
## [341] -0.4419343800 -0.0227867665 -0.4350540939 -0.9316725369 -0.4175561002  
## [346] -0.1487490039 -0.2093939086 -0.5303315919 1.7446224874 -0.2612226329  
## [351] -0.5132870153 0.8335564846 -0.5872185342 -0.0124791481 -0.8883339558  
## [356] -0.4533288566 -0.1931562655 0.6332367052 -0.5309710107 0.4846447569  
## [361] -3.4190569454 1.3533187300 -0.7304186920 -1.6543950316 0.9775415955  
## [366] 1.0153746477 -0.3170761509 0.0350515560 -0.9810646061 -0.0783573740  
## [371] 0.5589600106 -0.2208948744 -1.0057116560 -1.1436922857 -0.7446502255  
## [376] -1.1837133624 0.1426995783 -1.3399085787 -2.1205237469 0.4839192702  
## [381] -0.2029105770 2.5116381093 -1.0968208802 -0.4662682902 -0.9056899618  
## [386] 1.6799155925 -0.7633154639 -0.4435021851 0.8967055584 0.3784681703  
## [391] -0.7211795816 -0.4870884913 1.1601440088 1.1876367537 0.1523113414  
## [396] -0.9795202909 -0.0992835818 -1.9062621498 -0.8934170262 2.5437049124  
## [401] 1.3509636675 -0.5543138715 -0.1736388029 -0.3137980326 0.0138642485  
## [406] 0.8272932017 0.4029271664 -0.2668506755 1.1028071583 -0.2433587583  
## [411] -0.1934977949 1.0293771599 -0.1595481512 -0.4717514299 -0.3800251100  
## [416] -0.2570799451 0.9620452939 -0.1119030771 -0.0745761804 -1.5731841370  
## [421] 0.0379494677 0.6086366588 0.3044219302 1.8426776753 0.6456508095  
## [426] 1.1949946987 0.6276424274 0.2503392785 2.0594817150 -0.1123668992  
## [431] 0.1786275293 0.2388432785 0.0962701675 2.0012672104 -1.3044209413  
## [436] 0.2895505015 -0.1490929386 0.2129146117 -0.2219895874 -1.1126013844  
## [441] 0.7111730479 0.0804840097 -1.4199411769 0.6182981746 -1.4795312742  
## [446] -0.5959416539 0.9181502482 1.2374470107 -0.5747956993 1.7948518508  
## [451] -0.6243824640 -1.3572649341 -1.1386671552 -0.2543075709 0.4728763290  
## [456] 0.0248386042 -0.8836115436 -0.1169478755 -0.3588348264 0.9826655212  
## [461] 0.4614930944 0.3707516755 0.4538124260 1.0466950426 -0.5639278900  
## [466] 1.8407286568 0.1641991373 -1.4066999401 2.3103376163 0.2805138134  
## [471] 0.4360129557 0.7203101549 -0.0755028539 -1.1909634942 -0.3478978221  
## [476] 0.5875793354 0.9554057196 -0.1516317317 -0.7104236537 -0.2783928189  
## [481] -0.3014376446 0.5007375270 0.6810099416 -0.7446288642 -1.0559739525  
## [486] 0.4520167858 0.3855463902 0.6192422863 -0.6720193475 -0.3240109805  
## [491] 0.5561376322 -0.9619123529 1.5452303381 0.7334167166 -0.3167697354  
## [496] -1.8704119249 -0.9655076414 0.8547948541 1.3732408392 0.3921047034  
## [501] -1.2311932674 -1.5688894457 -0.4231806523 0.2923361130 -1.2497971305  
## [506] 2.1797623735 0.8631142499 0.7647032437 0.4988851011 1.5157943877  
## [511] -0.2279647073 1.0132544445 -1.6233487303 -0.8180321713 1.0435939456  
## [516] 1.4041661262 -1.6790644061 -0.6150491320 -0.6359001686 0.4715444744  
## [521] -1.5121776391 -0.1432452665 -2.6329155766 1.5866114250 -0.5972186301  
## [526] 1.4990582718 0.9860669596 -0.6562645492 -0.7077080077 0.0360552557  
## [531] 1.0920027205 1.2599491745 -1.5323972265 0.0911956362 1.0285004687  
## [536] -1.6601049469 0.7863386361 1.7377593782 1.0801067936 -0.6422844160  
## [541] 0.5733043266 -0.7033658751 -1.9707661888 -0.5098891158 0.6534734379  
## [546] -1.6124503907 -0.6885070339 1.0556840611 0.2192060049 -0.4478928003  
## [551] -0.3401067756 -1.4007089775 -0.0036215295 0.6590996917 -0.2810869283  
## [556] 0.2946574225 -0.6004763445 0.4208460994 -0.8163732002 -0.9331403994  
## [561] -0.5040703901 -0.9978276653 -0.0060839267 -0.6389113069 0.7474296157  
## [566] 0.2919576770 -0.9453760288 -0.7338431531 -0.6563224663 1.7596955790  
## [571] -1.5756347197 -0.0897184190 -0.2031586028 -0.3450992200 -0.5035652425  
## [576] -0.5013901772 -1.1907859427 0.8989841536 0.4161597439 0.3821366074  
## [581] 1.9687598150 0.8783308007 1.6047236658 -0.2931721081 -0.1551778688  
## [586] 0.6556258543 -1.8241154898 0.4150429297 0.2196254568 0.2696904294  
## [591] -0.3579409456 1.1836965837 0.7858543386 -0.4407695871 0.3465258349  
## [596] 0.1788354964 -1.1314094349 -0.1058451096 -0.4353776610 -0.8392205490  
## [601] -1.3379972868 0.7438724967 0.4082713748 0.3188817246 0.6193107306  
## [606] 0.2225119939 -0.1393627319 0.6117292623 0.6310151061 0.2245689269  
## [611] -1.7394753730 0.7005777100 0.6971283306 0.7621855652 0.7715788678  
## [616] -2.3328342889 -0.4706441746 0.8704148033 -1.2325494534 0.9003896987  
## [621] -0.0319482389 1.0155638933 -0.5788311547 -0.9782823772 0.5178635416  
## [626] 0.3791533188 -1.2478328473 0.5643797510 -1.2545276331 -0.0475714868  
## [631] -0.2667453062 0.1121513937 -1.3297567065 1.9310936360 -0.9551107755  
## [636] 0.2871886822 0.0261198054 -0.7918922437 0.1410536076 -0.4278445792  
## [641] 0.3691265059 0.9442129156 -0.3997244238 -0.7689480698 1.1687314174  
## [646] -1.3706274034 0.2547477159 -1.8434462499 -0.8318115260 0.9531050953  
## [651] 0.3374505427 -0.6852926781 0.6639222321 -1.2261145831 -0.2373320086  
## [656] 0.5928373070 -0.8766509943 0.3670353321 0.6589602708 -0.9371081449  
## [661] 0.3779453689 -0.3189224554 -0.1864964240 0.3469381323 1.6493005380  
## [666] -0.0306771935 0.3967473136 0.0265826813 0.8556186420 0.3499449791  
## [671] 1.0865435848 -1.1877708273 -0.2635594411 -1.6164140591 1.6759373176  
## [676] 0.2647187034 -0.7177643517 0.7853752694 -0.7665294047 -0.2521586497  
## [681] -0.6015253536 -0.0488819644 -0.7545268497 -1.1082129423 0.3249164776  
## [686] 2.2247261996 -0.0939882396 0.7047269370 -0.6523233395 -0.9912056562  
## [691] -0.0798062579 -0.9303219884 1.4527482983 -0.2167086390 -1.0862960373  
## [696] -0.0731419533 -1.1842452537 -1.9657325355 0.2390843029 -0.8250528095  
## [701] 0.4232389794 0.1811314688 1.7125107369 -1.4983091308 1.1090540984  
## [706] -0.5682880627 -1.3942625296 -0.5896295753 1.6779858447 -0.1290108247  
## [711] 0.4217942197 -0.4235287095 1.2112583997 -0.2199205594 1.2622724038  
## [716] 0.1594238696 1.0420753274 -0.4515255114 0.5867217914 1.6893145779  
## [721] -1.9274622034 0.6637052728 0.5847367474 -0.0045197966 -1.6344727078  
## [726] -0.2709760906 -2.4628102978 0.3758265760 0.3485657708 0.6028529142  
## [731] 0.8445449559 -1.0874743101 0.0521323486 -0.0578306539 -0.2396341430  
## [736] -0.0200774853 0.0827865679 0.4493132307 0.8303194402 0.9304488474  
## [741] 0.8153143220 -0.5200293293 -1.1752525566 1.2004483387 -0.0574652988  
## [746] -1.2292255611 1.3913747965 0.2305817326 1.4098981322 -1.0425411726  
## [751] -0.2284294573 -0.7538268512 -0.8851253281 -0.8995056561 0.0501201551  
## [756] 1.3811329671 1.0692451788 0.5496071514 -0.4477324655 -1.4644822585  
## [761] 0.2897392797 -0.7527793879 -1.1074186020 1.4133473769 0.7678200930  
## [766] -0.4052118937 1.6206223994 2.1693923452 -0.3283705767 -0.3070357954  
## [771] 1.1726102271 0.4343161986 2.5239991529 1.0401743673 1.2221918217  
## [776] -1.1350231090 -0.3664584470 -0.6515018994 1.8185549429 1.3741723199  
## [781] -0.4157243770 -0.4988133040 0.6573168879 -1.5898487580 -0.6707164473  
## [786] -0.8146612937 0.1189130800 1.0289712863 -0.1449252440 0.1121162728  
## [791] 0.2374627652 1.7550211372 -0.8290154029 2.1457038379 -0.3030070333  
## [796] 1.4466594159 -0.4618998365 1.8074057102 -1.1876686734 0.7180435615  
## [801] -0.2400370963 0.9180729844 0.3636619910 -0.7936376891 0.2457707084  
## [806] 0.8338911194 -1.3797578963 -1.4501339677 0.0414938866 0.5418679013  
## [811] -0.3932411647 -0.5865608347 1.5811947358 -0.5987828317 -0.7432341743  
## [816] 0.5993849257 -1.1828197646 -0.4804506355 -1.0231981246 1.0887659300  
## [821] 1.3511085009 -1.7746647626 -0.9642021666 -1.0362544834 0.1232385373  
## [826] -1.2275399393 0.1990075924 -1.2459314796 -0.2895393310 -0.0462361944  
## [831] -0.7890999353 -0.7570827793 0.6748605492 -0.3315427483 -0.5532875332  
## [836] 1.5339246547 2.0251666003 0.5874861858 0.8889507262 -1.0764489900  
## [841] -0.6827732569 -0.9406402816 -0.7490696341 -0.6441873848 -0.0750157960  
## [846] 0.2264466488 2.1684906065 -1.8501137557 0.1126448537 0.9085818304  
## [851] -0.8141859221 -0.5721913169 -0.3903589201 -1.1654846024 -0.3386858823  
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## [876] 1.2039084853 0.5779841156 -1.7534654854 -0.0352817251 0.1948952607  
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## [886] 0.4900763669 0.6094254761 0.0623876383 0.5966889583 0.6060518332  
## [891] 0.1520145910 -0.4131753917 -1.6077168763 0.9054570135 -0.2034311627  
## [896] -0.4139287792 -1.0028894065 -1.6394620481 -0.7904867642 0.2088450570  
## [901] -0.3354131882 1.1732197003 -1.7418461419 0.6123145778 0.9947435518  
## [906] -0.2283474573 -0.4529680663 -0.0990967759 -1.4153032974 -1.8334696795  
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## [916] 0.5356865016 -0.5856568288 0.5900539733 0.5121799318 0.8238554547  
## [921] 0.2879567454 0.7004300932 0.5991509444 -0.9259805422 0.2661057850  
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## [946] 1.0015032580 0.3410920631 1.4233960328 -0.5842957231 -0.9850631531  
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## [956] -1.0188173051 0.4154209203 -1.4075860787 -0.0006466527 1.1977316493  
## [961] -1.3448163175 -0.2615543403 0.0910478725 0.9021035632 0.9359587827  
## [966] 0.9530835679 -0.1778718905 -1.7445267909 0.3206307357 -0.9953206399  
## [971] -0.1092750364 0.7555502627 -0.9568987308 -1.7409089645 0.4115610166  
## [976] 0.3225185884 0.7916483729 0.5093550437 1.8761126184 -0.8381285001  
## [981] 0.1382590883 1.7311458767 1.0184620078 -2.2091150319 -0.3274524238  
## [986] -0.3784357400 -0.7444414492 -0.1728329870 0.5838442845 -1.2645838060  
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## [996] 0.4957224642 0.9789949429 0.4005794231 -0.9812645797 1.2114911370  
## [1001] 0.8909300315 0.7536161765 0.5004253135 0.9681790611 0.4456705392  
## [1006] -2.3444926402 2.1171885686 -0.4336685476 -0.2426448229 0.6309197318  
## [1011] -1.1432416398 0.5834749103 0.8107843078 -0.8000835653 -1.4022658829  
## [1016] 0.1132310613 0.0829455254 0.5193015247 -0.9938375968 -0.8844754005  
## [1021] 0.5427955987 -0.2679503886 -0.6696928320 1.6615146667 0.2602796629  
## [1026] 0.9559106898 -0.6962219616 -1.7439453351 1.2372517560 -0.0628906138  
## [1031] -0.6693599433 1.9527020308 -0.7404054203 -0.5977249077 -1.1789638835  
## [1036] -0.1590150822 1.1074261427 -0.7230707236 -0.6814135089 0.4947296504  
## [1041] 0.5267185503 -0.2978724730 -0.2698192229 -0.0675129134 0.2993868595  
## [1046] -0.1279543410 0.3315686848 0.4164332672 0.3902052853 -0.4630903368  
## [1051] -0.4572019444 0.1615497571 0.6914219277 -0.3569308339 0.1750403660  
## [1056] -0.3530388274 0.8548830221 -1.4937440062 -1.4834880078 0.1046742376  
## [1061] 0.2562768358 0.7356978586 -0.8745310980 0.8627339813 -1.5893492138  
## [1066] -2.0992221952 -0.5864531286 0.3369118404 1.8334913741 0.4135866522  
## [1071] 0.5769124007 -0.5377384263 1.2060089530 -0.0780768078 1.7194563843  
## [1076] -1.0844503611 -0.6953100104 0.4799168203 -0.7486297312 -1.6700988748  
## [1081] 0.2318518698 -0.4115878574 -1.1106981712 -0.0621596707 -0.5087186096  
## [1086] 0.5651903183 0.6320649166 1.6207056878 -1.1495810778 0.0450508486  
## [1091] -2.0182980956 0.0958704983 0.4291845424 -0.0867541549 -0.5783927128  
## [1096] 0.7196689515 0.9510367182 0.4930948529 1.6517822570 -0.4831687123  
## [1101] 1.0084971260 -1.5710997236 -2.7968775554 0.4592452913 -1.3133377183  
## [1106] 0.9195757179 -0.2119386661 -0.2802934355 1.1099241159 -0.2264895473

# with the indices i and j ranging over {1, . . . , n} and {1, . . . , m},   
# respectively.  
# We use the notation A n×m to refer to the matrix A and simultaneously to  
# indicate that it is n × m, and we use the notation  
# IR n×m  
m <- 12  
i <- c(1,1,1,n)  
j <- c(1,1,1,m)  
  
i \* j

## [1] 1 1 1 12

# to refer to the set of all n × m matrices with real elements.  
# We use the notation (A) ij to refer to the element in the i th row and the  
# th  
# j column of the matrix A; that is, in equation (1.3), (A) ij = a ij .  
# Although vectors are column vectors and the notation in equations (1.1)  
# and (1.2) represents the same entity, that would not be the same for matrices.  
# If x 1 , . . . , x n are scalars  
ij <- i  
j <- a  
ij <- a  
  
ij

## [1] 0.1992740687 1.1031479721 0.4400549175 0.5715046990 -1.3199755220  
## [6] 1.5756413991 -0.1576403251 -2.1950963845 -0.9185996204 -0.6747566260  
## [11] -0.6796626399 -1.1427551659 0.7070369018 -0.3204232617 0.4223483626  
## [16] 1.4971268995 0.7176519360 1.1654609829 -0.0073939184 -0.6001975519  
## [21] 1.5641453063 0.0775014664 -1.6339810701 -0.8084488163 1.2323994900  
## [26] 0.3315719949 -0.3728143168 -0.2170487486 0.5616044329 -0.6964363484  
## [31] -0.6181568282 -1.3831683126 1.2030212387 -0.3056304070 -1.3605070553  
## [36] -0.9423341680 1.4008430371 0.3376552232 0.0845937445 -0.2025962023  
## [41] -0.5747335794 0.8622152296 -0.0394137003 -0.0406165397 0.8636600589  
## [46] 0.6053405680 -0.5368847626 0.3689696831 0.8469908067 1.1339031985  
## [51] 1.3570942345 -2.7074503091 0.1375289098 -1.6131823120 1.3405254363  
## [56] -1.3990794723 -0.1257456927 -0.9208827702 -1.1951912414 -0.0563039011  
## [61] 1.5744182767 0.2089279879 -0.2573802041 -1.4102182718 -0.7647492453  
## [66] -0.9645508489 -1.7695400002 0.6021466565 0.0198169482 -0.6086816370  
## [71] -0.4319832850 0.3149292516 -0.0446669870 -0.2033412189 -0.6511484773  
## [76] 1.3994818672 -0.0026761943 -1.0318140588 0.4493164792 0.0213385806  
## [81] 0.9702526396 -0.4260420027 0.0654361398 -1.2472518366 -1.1433230906  
## [86] -1.1288244159 -0.2630907806 -0.2333170987 1.7489197374 1.0984182533  
## [91] -0.6159465206 -0.1755915268 0.0566065960 -0.2564774598 -0.3934734599  
## [96] -0.5469834928 0.1028997932 -0.0587559458 0.7648569324 -1.0632609252  
## [101] 0.0818294854 0.1909809791 -0.8392475691 0.1966370936 -1.9478973581  
## [106] 1.3412500669 -0.0805183395 0.8926756540 0.4435952195 -0.4749359403  
## [111] 1.0724488482 -0.0987160538 -1.9116528816 1.6644367925 0.9764633632  
## [116] 0.2563383381 -0.0839282471 -0.2649941653 1.2006261139 1.1260575395  
## [121] -1.4614673035 2.2854268197 -0.7838739262 -0.7363068530 -0.5414678829  
## [126] 0.6985110270 -0.7903663196 -0.0353087992 -0.1183879748 0.7130602684  
## [131] 0.6239860476 -2.6674261237 -0.3907404766 0.5802405216 -0.5891665240  
## [136] 0.0618198868 0.7843479079 -1.9764348741 1.2357394620 -0.6449419740  
## [141] -0.5536087361 0.9427577807 -0.4130599658 -1.8224682553 -1.3685051835  
## [146] -0.5908226644 1.9488147314 -1.1704613322 1.0785760444 -0.3521000070  
## [151] 0.2896709451 -0.4227009578 -1.6423790778 0.0418567663 -0.8526235475  
## [156] -0.6077738960 0.4049142291 -0.7442304366 0.8130760174 -0.7443272270  
## [161] 0.0582660804 0.3154474351 0.7058903064 -0.0606413210 1.4654657694  
## [166] 1.1529910080 0.9767076648 -0.9343373874 -0.9271343503 -0.5725557675  
## [171] 1.3333217315 -0.2709980536 0.8100788006 -1.1570475653 -0.0735254849  
## [176] -1.1029623557 0.2139824363 0.5220191719 -1.5720071225 1.4683287634  
## [181] 0.1272609124 -0.3970770062 -0.8193402512 0.0149641719 -0.1041616415  
## [186] -0.6519516594 -0.6072606642 1.1925636523 1.0258544116 -1.3638298221  
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## [201] -2.9547925402 -2.3338328778 -2.0925673839 -1.9050322242 -1.2312929260  
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## [221] -0.6991121368 1.0454935849 0.0642456117 -0.1171837494 -1.7101442876  
## [226] 0.7109954540 -1.2190654688 0.3557308027 1.4355022576 -0.2912630599  
## [231] -0.7426320504 0.0431133318 0.7326314951 -0.1861243682 -0.4969439598  
## [236] 0.9921069479 -0.4032362345 1.2438568387 -0.1605339928 -1.8475072222  
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## [246] 2.2039924596 -1.5397940800 0.0909668963 1.0352984203 1.6030139723  
## [251] 0.6096524435 1.5886993903 1.1628922882 0.7757201658 -0.5876741730  
## [256] -0.0553105405 1.4896527302 -0.2938401191 -1.7454420559 0.7242481043  
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## [296] -0.7685070643 -1.3972872304 0.8890678588 -0.2348425753 2.2032670779  
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## [311] -0.2268061411 0.5140066182 0.7442773632 -0.8809685459 -0.1908185589  
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## [376] -1.1837133624 0.1426995783 -1.3399085787 -2.1205237469 0.4839192702  
## [381] -0.2029105770 2.5116381093 -1.0968208802 -0.4662682902 -0.9056899618  
## [386] 1.6799155925 -0.7633154639 -0.4435021851 0.8967055584 0.3784681703  
## [391] -0.7211795816 -0.4870884913 1.1601440088 1.1876367537 0.1523113414  
## [396] -0.9795202909 -0.0992835818 -1.9062621498 -0.8934170262 2.5437049124  
## [401] 1.3509636675 -0.5543138715 -0.1736388029 -0.3137980326 0.0138642485  
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## [496] -1.8704119249 -0.9655076414 0.8547948541 1.3732408392 0.3921047034  
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## [506] 2.1797623735 0.8631142499 0.7647032437 0.4988851011 1.5157943877  
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## [526] 1.4990582718 0.9860669596 -0.6562645492 -0.7077080077 0.0360552557  
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## [566] 0.2919576770 -0.9453760288 -0.7338431531 -0.6563224663 1.7596955790  
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## [641] 0.3691265059 0.9442129156 -0.3997244238 -0.7689480698 1.1687314174  
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## [401] 1.3509636675 -0.5543138715 -0.1736388029 -0.3137980326 0.0138642485  
## [406] 0.8272932017 0.4029271664 -0.2668506755 1.1028071583 -0.2433587583  
## [411] -0.1934977949 1.0293771599 -0.1595481512 -0.4717514299 -0.3800251100  
## [416] -0.2570799451 0.9620452939 -0.1119030771 -0.0745761804 -1.5731841370  
## [421] 0.0379494677 0.6086366588 0.3044219302 1.8426776753 0.6456508095  
## [426] 1.1949946987 0.6276424274 0.2503392785 2.0594817150 -0.1123668992  
## [431] 0.1786275293 0.2388432785 0.0962701675 2.0012672104 -1.3044209413  
## [436] 0.2895505015 -0.1490929386 0.2129146117 -0.2219895874 -1.1126013844  
## [441] 0.7111730479 0.0804840097 -1.4199411769 0.6182981746 -1.4795312742  
## [446] -0.5959416539 0.9181502482 1.2374470107 -0.5747956993 1.7948518508  
## [451] -0.6243824640 -1.3572649341 -1.1386671552 -0.2543075709 0.4728763290  
## [456] 0.0248386042 -0.8836115436 -0.1169478755 -0.3588348264 0.9826655212  
## [461] 0.4614930944 0.3707516755 0.4538124260 1.0466950426 -0.5639278900  
## [466] 1.8407286568 0.1641991373 -1.4066999401 2.3103376163 0.2805138134  
## [471] 0.4360129557 0.7203101549 -0.0755028539 -1.1909634942 -0.3478978221  
## [476] 0.5875793354 0.9554057196 -0.1516317317 -0.7104236537 -0.2783928189  
## [481] -0.3014376446 0.5007375270 0.6810099416 -0.7446288642 -1.0559739525  
## [486] 0.4520167858 0.3855463902 0.6192422863 -0.6720193475 -0.3240109805  
## [491] 0.5561376322 -0.9619123529 1.5452303381 0.7334167166 -0.3167697354  
## [496] -1.8704119249 -0.9655076414 0.8547948541 1.3732408392 0.3921047034  
## [501] -1.2311932674 -1.5688894457 -0.4231806523 0.2923361130 -1.2497971305  
## [506] 2.1797623735 0.8631142499 0.7647032437 0.4988851011 1.5157943877  
## [511] -0.2279647073 1.0132544445 -1.6233487303 -0.8180321713 1.0435939456  
## [516] 1.4041661262 -1.6790644061 -0.6150491320 -0.6359001686 0.4715444744  
## [521] -1.5121776391 -0.1432452665 -2.6329155766 1.5866114250 -0.5972186301  
## [526] 1.4990582718 0.9860669596 -0.6562645492 -0.7077080077 0.0360552557  
## [531] 1.0920027205 1.2599491745 -1.5323972265 0.0911956362 1.0285004687  
## [536] -1.6601049469 0.7863386361 1.7377593782 1.0801067936 -0.6422844160  
## [541] 0.5733043266 -0.7033658751 -1.9707661888 -0.5098891158 0.6534734379  
## [546] -1.6124503907 -0.6885070339 1.0556840611 0.2192060049 -0.4478928003  
## [551] -0.3401067756 -1.4007089775 -0.0036215295 0.6590996917 -0.2810869283  
## [556] 0.2946574225 -0.6004763445 0.4208460994 -0.8163732002 -0.9331403994  
## [561] -0.5040703901 -0.9978276653 -0.0060839267 -0.6389113069 0.7474296157  
## [566] 0.2919576770 -0.9453760288 -0.7338431531 -0.6563224663 1.7596955790  
## [571] -1.5756347197 -0.0897184190 -0.2031586028 -0.3450992200 -0.5035652425  
## [576] -0.5013901772 -1.1907859427 0.8989841536 0.4161597439 0.3821366074  
## [581] 1.9687598150 0.8783308007 1.6047236658 -0.2931721081 -0.1551778688  
## [586] 0.6556258543 -1.8241154898 0.4150429297 0.2196254568 0.2696904294  
## [591] -0.3579409456 1.1836965837 0.7858543386 -0.4407695871 0.3465258349  
## [596] 0.1788354964 -1.1314094349 -0.1058451096 -0.4353776610 -0.8392205490  
## [601] -1.3379972868 0.7438724967 0.4082713748 0.3188817246 0.6193107306  
## [606] 0.2225119939 -0.1393627319 0.6117292623 0.6310151061 0.2245689269  
## [611] -1.7394753730 0.7005777100 0.6971283306 0.7621855652 0.7715788678  
## [616] -2.3328342889 -0.4706441746 0.8704148033 -1.2325494534 0.9003896987  
## [621] -0.0319482389 1.0155638933 -0.5788311547 -0.9782823772 0.5178635416  
## [626] 0.3791533188 -1.2478328473 0.5643797510 -1.2545276331 -0.0475714868  
## [631] -0.2667453062 0.1121513937 -1.3297567065 1.9310936360 -0.9551107755  
## [636] 0.2871886822 0.0261198054 -0.7918922437 0.1410536076 -0.4278445792  
## [641] 0.3691265059 0.9442129156 -0.3997244238 -0.7689480698 1.1687314174  
## [646] -1.3706274034 0.2547477159 -1.8434462499 -0.8318115260 0.9531050953  
## [651] 0.3374505427 -0.6852926781 0.6639222321 -1.2261145831 -0.2373320086  
## [656] 0.5928373070 -0.8766509943 0.3670353321 0.6589602708 -0.9371081449  
## [661] 0.3779453689 -0.3189224554 -0.1864964240 0.3469381323 1.6493005380  
## [666] -0.0306771935 0.3967473136 0.0265826813 0.8556186420 0.3499449791  
## [671] 1.0865435848 -1.1877708273 -0.2635594411 -1.6164140591 1.6759373176  
## [676] 0.2647187034 -0.7177643517 0.7853752694 -0.7665294047 -0.2521586497  
## [681] -0.6015253536 -0.0488819644 -0.7545268497 -1.1082129423 0.3249164776  
## [686] 2.2247261996 -0.0939882396 0.7047269370 -0.6523233395 -0.9912056562  
## [691] -0.0798062579 -0.9303219884 1.4527482983 -0.2167086390 -1.0862960373  
## [696] -0.0731419533 -1.1842452537 -1.9657325355 0.2390843029 -0.8250528095  
## [701] 0.4232389794 0.1811314688 1.7125107369 -1.4983091308 1.1090540984  
## [706] -0.5682880627 -1.3942625296 -0.5896295753 1.6779858447 -0.1290108247  
## [711] 0.4217942197 -0.4235287095 1.2112583997 -0.2199205594 1.2622724038  
## [716] 0.1594238696 1.0420753274 -0.4515255114 0.5867217914 1.6893145779  
## [721] -1.9274622034 0.6637052728 0.5847367474 -0.0045197966 -1.6344727078  
## [726] -0.2709760906 -2.4628102978 0.3758265760 0.3485657708 0.6028529142  
## [731] 0.8445449559 -1.0874743101 0.0521323486 -0.0578306539 -0.2396341430  
## [736] -0.0200774853 0.0827865679 0.4493132307 0.8303194402 0.9304488474  
## [741] 0.8153143220 -0.5200293293 -1.1752525566 1.2004483387 -0.0574652988  
## [746] -1.2292255611 1.3913747965 0.2305817326 1.4098981322 -1.0425411726  
## [751] -0.2284294573 -0.7538268512 -0.8851253281 -0.8995056561 0.0501201551  
## [756] 1.3811329671 1.0692451788 0.5496071514 -0.4477324655 -1.4644822585  
## [761] 0.2897392797 -0.7527793879 -1.1074186020 1.4133473769 0.7678200930  
## [766] -0.4052118937 1.6206223994 2.1693923452 -0.3283705767 -0.3070357954  
## [771] 1.1726102271 0.4343161986 2.5239991529 1.0401743673 1.2221918217  
## [776] -1.1350231090 -0.3664584470 -0.6515018994 1.8185549429 1.3741723199  
## [781] -0.4157243770 -0.4988133040 0.6573168879 -1.5898487580 -0.6707164473  
## [786] -0.8146612937 0.1189130800 1.0289712863 -0.1449252440 0.1121162728  
## [791] 0.2374627652 1.7550211372 -0.8290154029 2.1457038379 -0.3030070333  
## [796] 1.4466594159 -0.4618998365 1.8074057102 -1.1876686734 0.7180435615  
## [801] -0.2400370963 0.9180729844 0.3636619910 -0.7936376891 0.2457707084  
## [806] 0.8338911194 -1.3797578963 -1.4501339677 0.0414938866 0.5418679013  
## [811] -0.3932411647 -0.5865608347 1.5811947358 -0.5987828317 -0.7432341743  
## [816] 0.5993849257 -1.1828197646 -0.4804506355 -1.0231981246 1.0887659300  
## [821] 1.3511085009 -1.7746647626 -0.9642021666 -1.0362544834 0.1232385373  
## [826] -1.2275399393 0.1990075924 -1.2459314796 -0.2895393310 -0.0462361944  
## [831] -0.7890999353 -0.7570827793 0.6748605492 -0.3315427483 -0.5532875332  
## [836] 1.5339246547 2.0251666003 0.5874861858 0.8889507262 -1.0764489900  
## [841] -0.6827732569 -0.9406402816 -0.7490696341 -0.6441873848 -0.0750157960  
## [846] 0.2264466488 2.1684906065 -1.8501137557 0.1126448537 0.9085818304  
## [851] -0.8141859221 -0.5721913169 -0.3903589201 -1.1654846024 -0.3386858823  
## [856] -1.0449279387 0.5082822993 0.5541230496 0.0475181394 2.0103545105  
## [861] 0.2978226988 0.0122084805 -0.4199959789 -0.2549444976 -0.4556349900  
## [866] 0.8885398350 2.0784241813 -0.8985968468 -0.3667707838 -0.5817812507  
## [871] 1.7405551055 -0.5744623011 -1.4306875222 -1.2861757641 0.1218652422  
## [876] 1.2039084853 0.5779841156 -1.7534654854 -0.0352817251 0.1948952607  
## [881] -0.4059437969 -0.0876087210 0.6642700243 0.1449613200 -1.3609094099  
## [886] 0.4900763669 0.6094254761 0.0623876383 0.5966889583 0.6060518332  
## [891] 0.1520145910 -0.4131753917 -1.6077168763 0.9054570135 -0.2034311627  
## [896] -0.4139287792 -1.0028894065 -1.6394620481 -0.7904867642 0.2088450570  
## [901] -0.3354131882 1.1732197003 -1.7418461419 0.6123145778 0.9947435518  
## [906] -0.2283474573 -0.4529680663 -0.0990967759 -1.4153032974 -1.8334696795  
## [911] 0.7307972273 0.0243208300 -0.9548743669 -0.0993510098 -0.2131563769  
## [916] 0.5356865016 -0.5856568288 0.5900539733 0.5121799318 0.8238554547  
## [921] 0.2879567454 0.7004300932 0.5991509444 -0.9259805422 0.2661057850  
## [926] 0.5454627422 0.4323359017 0.4855019983 -0.7916233475 -0.2175360648  
## [931] 0.3141499993 1.2405016851 0.6221924525 -0.3400510346 1.0359660520  
## [936] -1.3556209239 0.0173255312 -2.1849076630 0.5055803323 1.0651602624  
## [941] -0.0179227000 -0.7556224076 -0.1234092393 -0.0734442746 -0.0477227477  
## [946] 1.0015032580 0.3410920631 1.4233960328 -0.5842957231 -0.9850631531  
## [951] 1.0125704863 1.4057888039 -0.0999086012 -0.2025419242 -0.9115385124  
## [956] -1.0188173051 0.4154209203 -1.4075860787 -0.0006466527 1.1977316493  
## [961] -1.3448163175 -0.2615543403 0.0910478725 0.9021035632 0.9359587827  
## [966] 0.9530835679 -0.1778718905 -1.7445267909 0.3206307357 -0.9953206399  
## [971] -0.1092750364 0.7555502627 -0.9568987308 -1.7409089645 0.4115610166  
## [976] 0.3225185884 0.7916483729 0.5093550437 1.8761126184 -0.8381285001  
## [981] 0.1382590883 1.7311458767 1.0184620078 -2.2091150319 -0.3274524238  
## [986] -0.3784357400 -0.7444414492 -0.1728329870 0.5838442845 -1.2645838060  
## [991] 2.1902107210 -0.2062034268 -0.6329150035 0.2638686167 -0.4190391034  
## [996] 0.4957224642 0.9789949429 0.4005794231 -0.9812645797 1.2114911370  
## [1001] 0.8909300315 0.7536161765 0.5004253135 0.9681790611 0.4456705392  
## [1006] -2.3444926402 2.1171885686 -0.4336685476 -0.2426448229 0.6309197318  
## [1011] -1.1432416398 0.5834749103 0.8107843078 -0.8000835653 -1.4022658829  
## [1016] 0.1132310613 0.0829455254 0.5193015247 -0.9938375968 -0.8844754005  
## [1021] 0.5427955987 -0.2679503886 -0.6696928320 1.6615146667 0.2602796629  
## [1026] 0.9559106898 -0.6962219616 -1.7439453351 1.2372517560 -0.0628906138  
## [1031] -0.6693599433 1.9527020308 -0.7404054203 -0.5977249077 -1.1789638835  
## [1036] -0.1590150822 1.1074261427 -0.7230707236 -0.6814135089 0.4947296504  
## [1041] 0.5267185503 -0.2978724730 -0.2698192229 -0.0675129134 0.2993868595  
## [1046] -0.1279543410 0.3315686848 0.4164332672 0.3902052853 -0.4630903368  
## [1051] -0.4572019444 0.1615497571 0.6914219277 -0.3569308339 0.1750403660  
## [1056] -0.3530388274 0.8548830221 -1.4937440062 -1.4834880078 0.1046742376  
## [1061] 0.2562768358 0.7356978586 -0.8745310980 0.8627339813 -1.5893492138  
## [1066] -2.0992221952 -0.5864531286 0.3369118404 1.8334913741 0.4135866522  
## [1071] 0.5769124007 -0.5377384263 1.2060089530 -0.0780768078 1.7194563843  
## [1076] -1.0844503611 -0.6953100104 0.4799168203 -0.7486297312 -1.6700988748  
## [1081] 0.2318518698 -0.4115878574 -1.1106981712 -0.0621596707 -0.5087186096  
## [1086] 0.5651903183 0.6320649166 1.6207056878 -1.1495810778 0.0450508486  
## [1091] -2.0182980956 0.0958704983 0.4291845424 -0.0867541549 -0.5783927128  
## [1096] 0.7196689515 0.9510367182 0.4930948529 1.6517822570 -0.4831687123  
## [1101] 1.0084971260 -1.5710997236 -2.7968775554 0.4592452913 -1.3133377183  
## [1106] 0.9195757179 -0.2119386661 -0.2802934355 1.1099241159 -0.2264895473

# then X is an n × 1 matrix and Y is a 1 × n matrix (and Y is the transpose  
# of X). Although an n × 1 matrix is a different type of object from a vector,  
X <- n \* 1  
Y <- 1 \* n  
  
X

## [1] 1

Y

## [1] 1

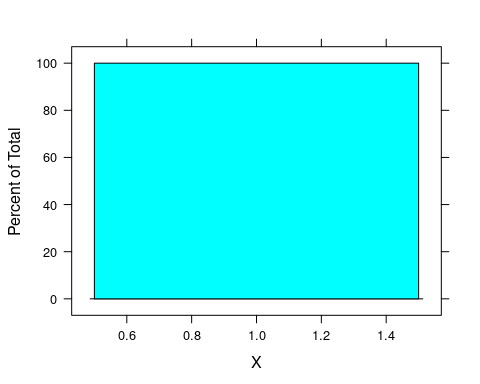
# we may treat X in equation (1.5) or Y T in equation (1.6) as a vector when  
# it is convenient to do so. Furthermore, although a 1 × 1 matrix, a 1-vector,  
# and a scalar are all fundamentally diﬀerent types of objects, we will treat a  
# one by one matrix or a vector with only one element as a scalar whenever it  
# is convenient.  
treering + X

## Time Series:  
## Start = -6000   
## End = 1979   
## Frequency = 1   
## [1] 2.345 2.077 2.545 2.319 2.413 2.069 1.489 2.171 1.887 1.493 1.346 1.846  
## [13] 1.837 1.079 1.829 1.919 1.776 1.081 1.876 1.254 2.092 1.659 1.900 1.732  
## [25] 1.703 1.690 1.581 1.834 1.838 1.600 1.611 1.704 1.517 1.525 2.086 1.849  
## [37] 1.183 1.823 1.433 1.849 2.021 1.813 1.675 1.479 1.824 1.473 2.010 2.297  
## [49] 1.917 1.457 1.866 2.121 2.301 2.017 1.676 1.816 2.365 1.759 1.791 2.016  
## [61] 1.959 1.966 2.355 1.966 1.771 1.561 2.712 2.514 1.677 1.613 2.265 1.342  
## [73] 1.918 2.346 1.786 1.557 2.444 2.516 2.329 2.071 2.105 2.211 2.491 2.105  
## [85] 2.285 2.202 2.587 1.663 2.139 2.073 1.659 1.821 2.080 2.149 1.863 1.889  
## [97] 2.175 1.938 2.007 2.180 2.230 2.249 2.435 1.418 1.590 1.576 2.001 1.138  
## [109] 2.356 1.914 1.637 2.170 1.841 1.880 1.894 1.889 1.482 1.170 2.148 1.905  
## [121] 1.642 1.717 1.107 1.686 1.254 1.961 1.789 2.121 2.362 2.047 2.082 1.239  
## [133] 1.621 1.471 1.744 1.450 2.167 2.130 2.039 1.329 2.351 2.150 1.998 2.052  
## [145] 2.283 2.245 2.395 2.223 1.593 2.325 1.741 2.533 2.480 2.311 1.970 1.924  
## [157] 2.219 2.337 1.671 2.195 1.999 2.299 2.317 2.785 1.711 2.196 2.144 2.036  
## [169] 2.285 2.070 2.076 1.758 1.348 1.826 1.923 2.108 2.294 2.320 2.061 1.418  
## [181] 2.205 1.212 2.315 2.186 1.995 1.914 1.728 2.068 1.896 1.881 1.483 1.490  
## [193] 2.095 2.379 1.832 2.101 1.876 1.992 2.013 1.873 2.065 1.621 2.041 2.108  
## [205] 2.114 2.082 1.851 2.085 2.390 2.406 2.163 2.387 2.357 1.463 1.547 2.277  
## [217] 2.108 1.996 2.085 2.391 2.075 1.913 2.299 2.259 2.320 2.122 2.491 2.298  
## [229] 2.112 2.305 2.133 2.180 2.284 2.276 2.099 1.881 2.000 2.173 2.130 2.084  
## [241] 1.999 2.235 2.119 2.049 2.089 2.233 2.304 2.280 2.208 1.874 1.962 2.372  
## [253] 2.224 2.117 2.121 2.480 2.675 2.298 1.996 2.306 2.027 1.823 2.424 2.041  
## [265] 1.463 2.130 1.909 2.369 1.982 2.080 2.419 2.286 2.581 1.875 1.359 1.319  
## [277] 1.874 2.145 1.807 1.964 1.892 1.442 1.948 2.013 1.897 2.153 2.145 1.628  
## [289] 1.325 2.325 2.047 1.911 2.376 1.975 2.099 1.632 1.934 2.175 1.810 1.855  
## [301] 2.407 2.126 2.148 1.787 1.835 2.101 1.761 1.907 2.149 1.865 1.785 2.250  
## [313] 1.646 1.937 1.925 1.792 2.212 1.987 1.409 2.062 1.634 2.006 2.210 2.315  
## [325] 1.960 1.470 2.010 1.729 2.212 1.851 2.114 2.016 1.954 1.380 2.178 2.251  
## [337] 2.194 2.103 2.258 1.836 2.136 1.884 1.498 1.084 2.286 1.490 2.037 1.986  
## [349] 2.073 1.381 2.001 1.878 2.136 1.783 1.917 1.802 1.866 1.728 2.264 2.203  
## [361] 2.402 2.347 2.234 2.069 2.356 2.526 2.345 1.790 2.500 1.752 1.940 2.121  
## [373] 2.186 2.065 2.164 2.469 1.817 1.185 2.433 2.555 2.201 2.317 1.955 2.005  
## [385] 1.901 1.821 1.479 1.750 1.182 1.936 2.058 2.074 1.934 1.903 1.309 1.786  
## [397] 1.585 1.811 1.969 2.089 1.581 1.990 1.900 1.800 1.771 1.919 1.800 1.658  
## [409] 1.328 1.698 1.929 1.677 1.401 2.109 1.274 1.668 1.960 1.221 2.025 2.083  
## [421] 1.593 1.994 1.861 1.588 1.923 2.107 1.693 1.882 1.591 1.660 2.075 2.146  
## [433] 1.965 1.795 2.061 1.946 1.705 1.744 2.063 2.182 2.136 2.229 1.653 1.892  
## [445] 1.696 1.465 1.962 2.170 1.911 2.293 2.088 1.853 2.146 1.578 1.900 1.975  
## [457] 2.191 1.481 1.155 2.455 2.233 1.930 2.131 2.304 2.393 2.128 1.801 2.619  
## [469] 2.423 2.606 2.395 2.291 2.456 2.674 2.256 2.135 2.190 2.167 2.065 2.292  
## [481] 1.575 2.505 2.239 1.993 1.925 1.988 2.171 2.133 2.412 2.070 2.272 1.790  
## [493] 2.082 2.179 2.109 2.588 2.053 2.123 2.246 2.361 1.860 1.146 2.252 2.350  
## [505] 1.907 2.464 2.067 1.827 1.769 1.875 1.668 1.999 2.252 2.439 2.206 1.797  
## [517] 1.724 1.867 2.333 2.306 2.058 2.440 2.239 2.611 2.403 1.754 1.129 2.075  
## [529] 1.841 1.752 2.446 2.010 2.034 2.016 1.396 2.101 1.645 2.342 2.146 1.943  
## [541] 1.755 2.406 1.860 1.890 2.010 1.850 1.444 1.573 1.190 1.985 1.873 2.209  
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## [565] 2.106 2.024 2.352 1.796 2.122 2.472 2.342 2.404 1.978 1.612 2.077 2.020  
## [577] 2.311 2.279 1.648 2.193 1.761 2.070 1.716 1.804 2.326 2.551 1.858 1.406  
## [589] 1.851 2.007 1.955 1.612 2.029 1.619 2.024 2.256 2.022 2.063 1.631 1.788  
## [601] 2.154 2.336 2.206 1.955 1.992 1.680 2.042 2.225 2.762 2.018 1.684 1.097  
## [613] 2.079 1.888 2.080 2.205 1.927 1.926 2.320 2.407 2.014 1.812 2.152 2.351  
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## [637] 1.809 1.217 1.157 1.588 1.748 2.109 2.096 1.626 1.907 1.767 2.178 1.887  
## [649] 1.599 1.930 2.149 2.052 2.187 2.309 1.973 1.908 2.330 1.624 2.660 1.967  
## [661] 2.397 2.289 2.587 2.517 2.254 2.077 2.147 2.234 2.646 2.657 2.844 2.288  
## [673] 1.875 2.053 2.229 2.051 2.665 1.298 2.272 2.277 2.458 2.139 1.613 1.091  
## [685] 1.803 1.251 1.877 1.875 1.909 1.371 2.433 2.517 2.119 2.316 2.265 2.187  
## [697] 2.225 2.064 1.793 2.148 1.761 2.264 1.681 2.103 1.339 1.930 2.182 2.540  
## [709] 2.397 2.429 1.573 2.658 2.243 2.339 2.433 2.484 1.652 2.185 2.416 2.365  
## [721] 1.959 2.065 2.047 2.396 1.215 2.383 1.943 2.474 2.136 2.134 2.339 2.633  
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## [757] 1.601 2.158 1.571 2.324 1.267 2.039 1.803 1.886 1.511 1.723 2.045 2.121  
## [769] 1.959 2.006 1.829 1.970 2.360 2.048 2.179 1.542 2.229 1.630 1.360 1.790  
## [781] 2.051 1.660 2.181 2.512 2.302 2.403 2.289 1.914 2.020 1.916 1.026 1.749  
## [793] 1.837 1.357 1.591 1.555 1.560 1.791 1.691 1.585 1.741 1.967 1.906 1.865  
## [805] 2.161 1.563 2.045 1.691 1.957 2.117 2.269 1.638 2.119 1.810 2.272 1.007  
## [817] 1.801 2.149 1.423 2.400 1.954 1.905 2.349 2.342 1.496 1.615 1.463 1.857  
## [829] 2.263 2.022 1.952 1.807 2.007 2.069 2.425 1.377 1.661 1.896 2.373 2.205  
## [841] 2.387 2.514 1.719 2.183 1.726 2.178 2.102 2.185 2.497 1.687 2.377 2.438  
## [853] 2.564 2.224 1.617 2.647 2.640 1.849 1.870 2.004 1.769 1.650 1.962 1.433  
## [865] 2.129 2.427 1.702 1.964 2.326 2.012 1.754 1.791 1.559 2.027 1.420 2.436  
## [877] 1.729 1.964 2.282 2.053 1.943 1.427 1.161 1.839 2.160 1.908 2.477 2.292  
## [889] 2.344 2.354 1.546 2.412 1.451 2.158 2.526 2.626 2.221 1.861 2.027 1.584  
## [901] 1.133 1.834 2.111 2.212 2.366 2.586 2.153 1.523 1.712 2.042 2.082 2.675  
## [913] 2.236 2.125 1.328 2.316 2.116 1.929 2.077 2.003 2.263 1.752 2.231 1.491  
## [925] 2.139 2.417 2.472 2.156 2.080 2.619 2.004 2.077 1.425 1.914 2.041 2.242  
## [937] 2.356 1.737 1.927 1.853 2.294 2.307 2.197 1.847 1.733 1.400 2.038 1.944  
## [949] 2.237 2.299 2.126 1.534 2.394 2.323 2.007 2.642 2.043 2.045 1.971 2.219  
## [961] 2.091 1.482 1.927 2.104 2.194 2.445 2.442 2.300 1.800 1.206 2.321 2.233  
## [973] 1.986 1.521 2.177 1.191 1.896 1.666 1.880 2.023 2.592 1.764 1.851 1.783  
## [985] 1.869 1.606 2.160 1.946 1.628 1.897 2.067 2.046 2.368 2.624 2.719 2.029  
## [997] 1.912 1.974 2.620 2.558 2.549 1.554 1.699 1.431 1.605 2.335 2.215 2.162  
## [1009] 2.040 2.029 2.209 1.653 2.060 1.285 1.925 2.084 1.681 1.266 1.692 1.893  
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## [1045] 1.990 1.753 2.269 2.262 2.124 2.107 2.515 2.245 2.144 1.851 2.381 2.197  
## [1057] 2.169 1.218 1.227 2.584 1.927 1.975 1.811 1.742 1.827 2.348 2.688 2.399  
## [1069] 1.757 1.801 2.362 1.964 1.242 2.094 1.847 2.203 2.089 2.233 2.173 2.115  
## [1081] 2.189 1.884 1.779 1.784 2.266 2.225 1.677 2.137 1.919 2.691 2.123 2.457  
## [1093] 2.223 2.119 1.565 1.907 1.945 1.942 2.509 2.486 1.945 1.582 2.075 1.969  
## [1105] 1.672 1.816 1.928 1.814 1.945 1.439 1.896 2.434 2.211 2.519 2.068 1.677  
## [1117] 2.323 1.794 2.124 2.057 1.933 2.222 2.039 1.958 1.357 1.562 2.055 1.706  
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## [1177] 1.651 2.007 2.345 2.436 1.809 1.721 1.723 2.121 2.028 1.599 2.407 1.562  
## [1189] 1.712 2.020 2.217 2.498 1.539 1.836 1.894 1.924 1.749 1.961 2.164 2.413  
## [1201] 2.062 1.481 1.721 2.160 1.682 1.653 2.496 2.116 1.929 1.668 2.334 1.775  
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## [1249] 2.290 1.737 1.618 2.056 2.130 2.490 2.242 1.786 1.549 1.709 1.419 2.435  
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## [1345] 2.239 2.750 2.124 1.872 1.963 1.965 2.068 2.169 2.132 2.129 2.011 1.680  
## [1357] 2.098 1.945 2.429 2.006 1.838 1.509 1.747 2.231 2.468 2.320 2.088 2.221  
## [1369] 1.327 2.043 2.003 1.013 1.360 1.091 2.565 2.170 2.365 1.919 1.916 2.005  
## [1381] 2.364 1.166 1.873 2.271 2.059 1.694 1.399 2.466 1.873 1.852 1.837 2.110  
## [1393] 1.564 2.153 1.000 2.252 2.013 1.508 1.834 2.121 1.991 2.207 2.518 2.027  
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## [1417] 2.568 2.170 2.214 2.274 2.040 2.143 2.365 1.866 2.121 1.618 2.271 2.549  
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## [1513] 1.976 1.221 1.786 1.918 1.915 1.946 1.629 2.123 2.025 1.854 2.187 1.572  
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## [1549] 2.076 2.227 2.036 2.028 2.510 2.493 2.137 1.669 2.175 1.789 2.423 2.334  
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## [1573] 1.486 1.891 2.200 2.339 1.850 1.829 2.453 2.276 1.744 2.403 1.788 1.663  
## [1585] 1.773 1.933 1.904 1.916 2.038 2.288 1.867 1.051 1.506 2.107 2.215 2.105  
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## [1669] 2.192 2.128 2.322 2.418 2.406 1.430 2.253 1.751 2.343 1.944 1.936 2.095  
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## [1741] 2.315 2.199 1.146 1.988 1.614 1.858 2.063 1.885 2.047 2.085 1.873 1.768  
## [1753] 2.129 1.676 1.743 1.514 1.795 1.923 2.028 2.383 2.081 2.036 2.454 1.970  
## [1765] 1.758 2.082 1.741 1.570 2.041 2.093 2.381 2.325 1.811 2.012 1.854 1.595  
## [1777] 2.015 1.890 1.807 1.719 2.119 1.980 2.281 2.172 1.832 2.033 2.161 1.948  
## [1789] 2.029 2.317 2.248 1.984 2.400 1.775 1.685 1.818 1.823 1.656 1.855 1.259  
## [1801] 1.134 1.873 1.607 1.647 1.978 1.894 1.580 1.476 1.693 2.075 1.930 2.122  
## [1813] 2.148 1.807 2.242 1.978 2.005 2.257 2.471 2.345 2.206 2.502 1.634 1.879  
## [1825] 1.799 1.963 2.114 2.344 2.052 1.988 1.340 2.037 1.346 1.528 2.197 2.323  
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## [1921] 1.764 1.827 1.765 1.789 2.055 1.859 2.078 1.300 1.839 2.052 2.280 2.423  
## [1933] 2.515 1.996 1.876 1.885 2.049 1.201 2.138 1.704 1.685 1.770 1.148 1.918  
## [1945] 1.469 1.984 1.850 1.534 1.696 1.852 1.648 1.542 1.869 2.204 2.361 2.195  
## [1957] 2.084 1.494 1.925 1.955 1.896 1.682 2.084 2.246 2.135 2.307 1.919 1.985  
## [1969] 1.903 2.004 1.532 1.865 1.944 2.017 1.780 1.644 1.901 2.144 1.928 1.705  
## [1981] 2.085 2.127 1.939 2.035 1.937 2.124 2.272 2.601 2.394 1.886 1.809 2.289  
## [1993] 1.932 1.781 1.834 2.445 2.374 2.090 1.837 2.643 2.410 1.995 2.041 2.389  
## [2005] 2.587 2.227 1.966 1.893 1.096 2.164 1.835 1.334 1.876 1.838 1.532 1.770  
## [2017] 2.079 2.204 2.135 1.405 1.986 2.115 2.159 2.227 2.506 2.070 2.292 2.326  
## [2029] 1.689 2.024 2.407 1.594 2.057 2.177 2.524 2.206 2.074 2.042 1.925 1.669  
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## [2197] 1.209 1.850 1.434 1.703 2.148 1.462 2.204 2.166 1.636 2.254 2.089 2.330  
## [2209] 2.128 2.221 2.313 2.041 1.910 1.938 1.856 1.827 2.010 1.932 2.075 1.919  
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## [2629] 2.147 1.958 1.602 1.872 1.794 1.758 1.910 2.036 2.122 2.546 1.685 1.897  
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## [49] 1.917 1.457 1.866 2.121 2.301 2.017 1.676 1.816 2.365 1.759 1.791 2.016  
## [61] 1.959 1.966 2.355 1.966 1.771 1.561 2.712 2.514 1.677 1.613 2.265 1.342  
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## [85] 2.285 2.202 2.587 1.663 2.139 2.073 1.659 1.821 2.080 2.149 1.863 1.889  
## [97] 2.175 1.938 2.007 2.180 2.230 2.249 2.435 1.418 1.590 1.576 2.001 1.138  
## [109] 2.356 1.914 1.637 2.170 1.841 1.880 1.894 1.889 1.482 1.170 2.148 1.905  
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## [133] 1.621 1.471 1.744 1.450 2.167 2.130 2.039 1.329 2.351 2.150 1.998 2.052  
## [145] 2.283 2.245 2.395 2.223 1.593 2.325 1.741 2.533 2.480 2.311 1.970 1.924  
## [157] 2.219 2.337 1.671 2.195 1.999 2.299 2.317 2.785 1.711 2.196 2.144 2.036  
## [169] 2.285 2.070 2.076 1.758 1.348 1.826 1.923 2.108 2.294 2.320 2.061 1.418  
## [181] 2.205 1.212 2.315 2.186 1.995 1.914 1.728 2.068 1.896 1.881 1.483 1.490  
## [193] 2.095 2.379 1.832 2.101 1.876 1.992 2.013 1.873 2.065 1.621 2.041 2.108  
## [205] 2.114 2.082 1.851 2.085 2.390 2.406 2.163 2.387 2.357 1.463 1.547 2.277  
## [217] 2.108 1.996 2.085 2.391 2.075 1.913 2.299 2.259 2.320 2.122 2.491 2.298  
## [229] 2.112 2.305 2.133 2.180 2.284 2.276 2.099 1.881 2.000 2.173 2.130 2.084  
## [241] 1.999 2.235 2.119 2.049 2.089 2.233 2.304 2.280 2.208 1.874 1.962 2.372  
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## [277] 1.874 2.145 1.807 1.964 1.892 1.442 1.948 2.013 1.897 2.153 2.145 1.628  
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## [337] 2.194 2.103 2.258 1.836 2.136 1.884 1.498 1.084 2.286 1.490 2.037 1.986  
## [349] 2.073 1.381 2.001 1.878 2.136 1.783 1.917 1.802 1.866 1.728 2.264 2.203  
## [361] 2.402 2.347 2.234 2.069 2.356 2.526 2.345 1.790 2.500 1.752 1.940 2.121  
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## [397] 1.585 1.811 1.969 2.089 1.581 1.990 1.900 1.800 1.771 1.919 1.800 1.658  
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## [421] 1.593 1.994 1.861 1.588 1.923 2.107 1.693 1.882 1.591 1.660 2.075 2.146  
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## [781] 2.051 1.660 2.181 2.512 2.302 2.403 2.289 1.914 2.020 1.916 1.026 1.749  
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## [1789] 2.029 2.317 2.248 1.984 2.400 1.775 1.685 1.818 1.823 1.656 1.855 1.259  
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## [1921] 1.764 1.827 1.765 1.789 2.055 1.859 2.078 1.300 1.839 2.052 2.280 2.423  
## [1933] 2.515 1.996 1.876 1.885 2.049 1.201 2.138 1.704 1.685 1.770 1.148 1.918  
## [1945] 1.469 1.984 1.850 1.534 1.696 1.852 1.648 1.542 1.869 2.204 2.361 2.195  
## [1957] 2.084 1.494 1.925 1.955 1.896 1.682 2.084 2.246 2.135 2.307 1.919 1.985  
## [1969] 1.903 2.004 1.532 1.865 1.944 2.017 1.780 1.644 1.901 2.144 1.928 1.705  
## [1981] 2.085 2.127 1.939 2.035 1.937 2.124 2.272 2.601 2.394 1.886 1.809 2.289  
## [1993] 1.932 1.781 1.834 2.445 2.374 2.090 1.837 2.643 2.410 1.995 2.041 2.389  
## [2005] 2.587 2.227 1.966 1.893 1.096 2.164 1.835 1.334 1.876 1.838 1.532 1.770  
## [2017] 2.079 2.204 2.135 1.405 1.986 2.115 2.159 2.227 2.506 2.070 2.292 2.326  
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## [7465] 2.266 1.972 2.082 2.328 1.756 2.185 2.323 2.100 2.148 1.903 1.864 1.728  
## [7477] 1.711 2.183 2.144 1.585 1.998 2.228 1.958 2.104 2.593 2.202 2.403 2.740  
## [7489] 2.139 2.428 2.549 2.250 1.472 2.148 2.467 2.105 1.872 1.077 1.942 1.950  
## [7501] 1.216 2.132 2.366 2.055 1.862 1.745 1.832 2.017 1.863 2.036 2.329 2.086  
## [7513] 1.855 1.792 2.180 1.573 2.167 2.218 1.992 1.899 2.226 1.599 1.761 1.456  
## [7525] 2.089 1.992 2.099 2.048 1.702 1.709 1.952 1.906 1.881 1.685 2.059 2.120  
## [7537] 2.073 2.103 1.976 2.307 2.220 1.505 1.434 1.899 1.590 1.636 1.882 1.784  
## [7549] 1.644 1.930 2.081 2.120 2.124 2.369 2.102 2.119 2.328 2.175 1.971 2.057  
## [7561] 2.250 2.400 2.267 2.356 2.377 2.337 1.942 2.325 2.345 2.101 2.302 1.242  
## [7573] 2.181 2.059 2.078 1.914 1.539 1.985 1.746 1.375 1.112 2.195 2.116 2.215  
## [7585] 2.187 1.602 2.054 2.157 2.008 2.316 1.363 2.135 1.507 1.985 2.320 2.035  
## [7597] 2.104 1.998 2.172 2.193 1.373 2.071 2.020 2.059 2.307 2.288 2.138 1.998  
## [7609] 2.214 2.316 2.273 2.182 1.768 1.670 2.022 2.371 2.456 2.608 2.346 2.128  
## [7621] 2.302 2.128 2.075 2.320 1.860 2.466 1.670 2.155 2.325 2.012 2.148 1.817  
## [7633] 1.704 2.139 2.280 2.214 2.264 2.056 1.914 2.349 2.313 1.984 1.732 2.333  
## [7645] 2.129 2.207 2.090 1.792 2.268 2.509 2.067 2.351 1.659 1.906 1.670 1.386  
## [7657] 1.782 2.000 1.818 1.942 1.939 2.118 2.033 1.922 1.998 1.688 2.031 2.061  
## [7669] 1.292 1.739 1.262 1.998 1.893 1.866 1.955 1.673 1.774 1.870 1.974 2.060  
## [7681] 2.204 1.732 2.248 2.186 1.451 1.876 1.390 1.922 2.020 1.877 1.670 1.966  
## [7693] 1.943 2.023 2.073 2.160 2.049 2.110 1.992 1.647 2.332 1.876 2.100 1.661  
## [7705] 1.925 2.129 2.223 1.580 1.702 2.055 2.237 2.033 2.199 1.960 2.088 2.068  
## [7717] 2.044 2.234 2.364 2.391 2.527 2.548 2.044 2.075 2.192 2.450 2.620 2.653  
## [7729] 2.610 1.898 2.432 2.024 2.278 1.774 2.190 1.360 2.127 1.628 1.773 1.730  
## [7741] 2.004 2.415 2.127 2.442 2.398 2.067 2.432 2.502 1.969 2.092 2.292 2.354  
## [7753] 1.884 1.501 1.936 1.957 1.863 1.768 2.147 1.550 2.345 1.820 2.348 1.644  
## [7765] 2.016 1.884 1.964 2.117 2.170 2.340 2.388 2.412 2.154 2.407 2.212 2.039  
## [7777] 2.090 1.312 2.034 2.075 2.055 1.902 1.181 1.630 2.009 2.140 1.990 2.039  
## [7789] 2.207 1.891 2.142 2.242 2.230 2.003 2.028 1.274 2.168 2.342 2.194 2.366  
## [7801] 2.268 2.248 2.468 2.304 2.436 2.055 2.019 2.063 2.153 2.178 2.189 2.261  
## [7813] 1.653 1.376 2.109 2.002 1.978 2.371 2.417 2.132 1.961 2.366 1.885 1.750  
## [7825] 1.626 2.189 2.137 2.298 2.348 1.400 2.193 2.252 2.002 2.384 1.888 1.854  
## [7837] 1.481 1.799 2.232 2.255 2.413 2.096 1.873 1.964 1.644 1.519 2.178 1.896  
## [7849] 2.108 2.147 2.193 1.942 2.300 2.355 2.406 2.424 1.339 1.494 1.766 1.770  
## [7861] 2.075 1.946 2.327 1.787 2.093 1.834 2.044 2.224 2.249 2.270 2.203 2.293  
## [7873] 2.398 1.912 2.155 2.017 1.993 1.804 2.028 1.729 1.927 1.859 2.021 1.921  
## [7885] 1.807 2.084 2.129 2.210 2.229 2.039 2.122 2.249 2.156 2.021 1.869 2.166  
## [7897] 1.622 2.048 2.132 1.234 2.030 2.274 2.006 2.083 1.882 2.409 2.113 2.274  
## [7909] 2.356 2.474 2.019 2.318 2.087 2.294 2.365 2.282 2.087 2.194 2.106 2.270  
## [7921] 2.148 2.504 2.449 1.513 1.983 1.783 2.190 1.908 1.878 1.247 2.107 1.956  
## [7933] 2.015 1.789 1.318 2.010 1.802 2.133 2.076 1.966 2.119 1.840 1.942 1.721  
## [7945] 1.884 1.913 2.136 1.985 1.656 1.799 1.394 2.176 1.963 1.997 1.799 1.729  
## [7957] 1.858 1.979 2.070 2.066 1.273 1.863 1.975 2.204 1.790 1.991 1.857 2.017  
## [7969] 1.897 2.239 1.446 1.960 1.597 2.229 2.031 2.027 2.173 2.471 2.444 2.160

# One of the most important uses of matrices is as a transformation of a vec-  
# tor by vector/matrix multiplication. Such transformations are linear (a term  
# that we deﬁne later). Although one can occasionally proﬁtably distinguish ma-  
# trices from linear transformations on vectors, for our present purposes there  
# is no advantage in doing so. We will often treat matrices and linear transfor-  
# mations as equivalent.  
lattice::histogram(X)



# Many of the properties of vectors and matrices we discuss hold for an  
# inﬁnite number of elements, but we will assume throughout this book that  
# the number is ﬁnite.  
Inf + X

## [1] Inf

Inf + Y

## [1] Inf

# Subvectors and Submatrices  
# We sometimes ﬁnd it useful to work with only some of the elements of a  
# vector or matrix. We refer to the respective arrays as “subvectors” or “sub-  
# matrices”. We also allow the rearrangement of the elements by row or column  
# permutations and still consider the resulting object as a subvector or subma-  
# trix. In Chapter 3, we will consider special forms of submatrices formed by  
# “partitions” of given matrices.  
  
# 1.4 Representation of Data  
# Before we can do any serious analysis of data, the data must be represented  
# in some structure that is amenable to the operations of the analysis. In sim-  
# pole cases, the data are represented by a list of scalar values. The ordering   
# in  
# the list may be unimportant, and the analysis may just consist of compute-  
# son of simple summary statistics. In other cases, the list represents a time  
# series of observations, and the relationships of observations to each other   
# as  
# a function of their distance apart in the list are of interest. Often, the   
# data  
# can be represented meaningfully in two lists that are related to each other   
# by  
# the positions in the lists. The generalization of this representation is a   
# two-  
# dimensional array in which each column corresponds to a particular type of  
# data.  
  
# A major consideration, of course, is the nature of the individual items of  
# data. The observational data may be in various forms: quantitative measures,  
# colors, text strings, and so on. Prior to most analyses of data, they must be  
# represented as real numbers. In some cases, they can be represented easily  
# as real numbers, although there may be restrictions on the mapping into the  
# reals. (For example, do the data naturally assume only integral values, or  
# could any real number be mapped back to a possible observation?)  
major <- RUnit::checkTrue(expr = TRUE, msg = "cured TRUE message real numbers")  
major

## [1] TRUE