**ĐẠI HỌC QUỐC GIA TP.HỒ CHÍ MINH**

**TRƯỜNG ĐẠI HỌC CÔNG NGHỆ THÔNG TIN**

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**BÁO CÁO THỰC HÀNH**

**MÔN C106.M21: TRÍ TUỆ NHÂN TẠO**

**LAB: Assignment 2 - Solving Knapsack Problems**

**Using Google OR Tools**

**Giảng viên hướng dẫn:** TS. Lương Ngọc Hoàng

**Sinh viên thực hiện:**

**Họ và tên** **MSSV**

1. Trương Thế Tấn 19522180

**TP. Hồ Chí Minh, tháng 4, năm 2022**

* Thời gian tối đa cho mỗi test case là: 7 phút ~ 420s.
* Thử nghiệm với 10 test case từ n00050 – n10000 của 13 nhóm testcase đã cho. Nhóm Test case n00500 và n10000 thử nghiệm với 2 test case thuộc nhóm R01000 và R10000. Tổng cộng 130 test case.
* Kết quả được cho là tối ưu khi test case được giải trong thời gian giới hạn đặt ra ở hàm set\_time\_limit(420).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Nhóm** | **Tên testcase** | **Giá trị lời giải** | **Tổng trọng lượng** | **Thời gian chạy (s)** | **Tối ưu** |
| **00**  **Uncorrelated**  **0.875s** | n00050/R10000/s002.kp | 205492 | 137.567 | 0 | **☑** |
| n00100/R10000/s003.kp | 434159 | 240.141 | 0 | **☑** |
| n00200/R10000/s005.kp | 859760 | 475490 | 0 | **☑** |
| n00500/R10000/s008.kp | 2062200 | 1218272 | 0 | **☑** |
| n00500/R01000/s008.kp | 206336 | 121939 | 0 | **☑** |
| n01000/R01000/s013.kp | 392980 | 253440 | 0 | **☑** |
| n02000/R01000/s021.kp | 812697 | 492924 | 0.015625 | **☑** |
| n05000/R01000/s034.kp | 2002220 | 1239358 | 0.09375 | **☑** |
| n10000/R01000/s055.kp | 4053038 | 2471231 | 0.375 | **☑** |
| n10000/R10000/s055.kp | 40507109 | 24690192 | 0.390625 | **☑** |
| **01**  **Weakly**  **Correlated**  **0.71875s** | n00050/R10000/s002.kp | 150517 | 135598 | 0 | **☑** |
| n00100/R10000/s003.kp | 290405 | 267889 | 0 | **☑** |
| n00200/R10000/s005.kp | 576879 | 530567 | 0.015625 | **☑** |
| n00500/R10000/s008.kp | 1401704 | 1282423 | 0 | **☑** |
| n00500/R01000/s008.kp | 140335 | 128354 | 0 | **☑** |
| n01000/R01000/s013.kp | 269899 | 243197 | 0.015625 | **☑** |
| n02000/R01000/s021.kp | 548590 | 497414 | 0 | **☑** |
| n05000/R01000/s034.kp | 1361922 | 1232334 | 0.078125 | **☑** |
| n10000/R01000/s055.kp | 2741440 | 2479611 | 0.296875 | **☑** |
| n10000/R10000/s055.kp | 27380175 | 24774073 | 0.3125 | **☑** |
| **02**  **Strongly**  **Correlated**  **2082.172s** | n00050/R10000/s002.kp | 169607 | 135607 | 0.015625 | **☑** |
| n00100/R10000/s003.kp | 336913 | 267913 | 0.296875 | **☑** |
| n00200/R10000/s005.kp | 668613 | 530613 | 0.21875 | **☑** |
| n00500/R10000/s008.kp | 1629426 | 1282426 | 250.5156 | **☑** |
| n00500/R01000/s008.kp | 163054 | 128354 | 233.8906 | **☑** |
| n01000/R01000/s013.kp | 313797 | 243197 | 0 | **☑** |
| n02000/R01000/s021.kp | 637376 | 496976 | 392.7656 | **☑** |
| n05000/R01000/s034.kp | 1584295 | 1232095 | 411.7344 | **☑** |
| n10000/R01000/s055.kp | 3182561 | 2479061 | 420.4531 | **□** |
| n10000/R10000/s055.kp | 31810592 | 24773592 | 372.2813 | **☑** |
| **03**  **Inverse**  **Strongly**  **Correlated**  **2676.000025s** | n00050/R10000/s002.kp | 143359 | 160359 | 0.265625 | **☑** |
| n00100/R10000/s003.kp | 284418 | 317418 | 415.4531 | **☑** |
| n00200/R10000/s005.kp | 564475 | 629475 | 0.1875 | **☑** |
| n00500/R10000/s008.kp | 1366131 | 1527131 | 251.5469 | **☑** |
| n00500/R01000/s008.kp | 136693 | 152793 | 197.3594 | **☑** |
| n01000/R01000/s013.kp | 261048 | 292348 | 225.2188 | **☑** |
| n02000/R01000/s021.kp | 532973 | 596173 | 325.8281 | **☑** |
| n05000/R01000/s034.kp | 1322457 | 1479757 | 419.75 | **☑** |
| n10000/R01000/s055.kp | 2659426 | 2974526 | 420.1875 | **□** |
| n10000/R10000/s055.kp | 26573296 | 29723296 | 420.2031 | **□** |
| **04**  **Almost**  **Strongly**  **Correlated**  **1519.8438s** | n00050/R10000/s002.kp | 169704 | 135605 | 0.015625 | **☑** |
| n00100/R10000/s003.kp | 336950 | 267913 | 0.09375 | **☑** |
| n00200/R10000/s005.kp | 668480 | 530607 | 0.015625 | **☑** |
| n00500/R10000/s008.kp | 1629483 | 1282426 | 319.5938 | **☑** |
| n00500/R01000/s008.kp | 163062 | 128354 | 0.3125 | **☑** |
| n01000/R01000/s013.kp | 313820 | 243197 | 9.5 | **☑** |
| n02000/R01000/s021.kp | 637553 | 497097 | 338.5469 | **☑** |
| n05000/R01000/s034.kp | 1584569 | 1232334 | 31.1875 | **☑** |
| n10000/R01000/s055.kp | 3183138 | 2479587 | 400.1406 | **☑** |
| n10000/R10000/s055.kp | 31805562 | 24769489 | 420.4375 | **□** |
| **05**  **SubsetSum**  **0.5625s** | n00050/R10000/s002.kp | 135607 | 135607 | 0 | **☑** |
| n00100/R10000/s003.kp | 267913 | 267913 | 0 | **☑** |
| n00200/R10000/s005.kp | 530613 | 530613 | 0 | **☑** |
| n00500/R10000/s008.kp | 1282426 | 1282426 | 0 | **☑** |
| n00500/R01000/s008.kp | 128354 | 128354 | 0 | **☑** |
| n01000/R01000/s013.kp | 243197 | 243197 | 0 | **☑** |
| n02000/R01000/s021.kp | 497414 | 497414 | 0.015625 | **☑** |
| n05000/R01000/s034.kp | 1232334 | 1232334 | 0.046875 | **☑** |
| n10000/R01000/s055.kp | 2479611 | 2479611 | 0.203125 | **☑** |
| n10000/R10000/s055.kp | 24774074 | 24774074 | 0.296875 | **☑** |
| **06**  **Uncorrelated**  **WithSimilar**  **Weights**  **2004.640675s** | n00050/R10000/s002.kp | 19477 | 2401507 | 0.03125 | **☑** |
| n00100/R10000/s003.kp | 39436 | 4902473 | 0.5 | **☑** |
| n00200/R10000/s005.kp | 79002 | 9904796 | 0 | **☑** |
| n00500/R10000/s008.kp | 189628 | 24712220 | 254.8906 | **☑** |
| n00500/R01000/s008.kp | 189628 | 24712220 | 266.6563 | **☑** |
| n01000/R01000/s013.kp | 366294 | 49525757 | 0.015625 | **☑** |
| n02000/R01000/s021.kp | 746569 | 99049110 | 338.1875 | **☑** |
| n05000/R01000/s034.kp | 1853391 | 247624825 | 303.7656 | **☑** |
| n10000/R01000/s055.kp | 3730750 | 495247320 | 420.2969 | **□** |
| n10000/R10000/s055.kp | 3730750 | 495247320 | 420.2969 | **□** |
| **07**  **Spanner**  **Uncorrelated**  **2555.67193s** | n00050/R10000/s002.kp | 155287 | 9987 | 0.15625 | **☑** |
| n00100/R10000/s003.kp | 116306 | 129351 | 10.54688 | **☑** |
| n00200/R10000/s010.kp | 298162 | 191546 | 198.4531 | **☑** |
| n00500/R10000/s008.kp | 787654 | 525776 | 247.3594 | **☑** |
| n00500/R01000/s008.kp | 78060 | 52300 | 297.0313 | **☑** |
| n01000/R01000/s013.kp | 150350 | 186725 | 263.3594 | **☑** |
| n02000/R01000/s021.kp | 346868 | 271510 | 300.8125 | **☑** |
| n05000/R01000/s034.kp | 702674 | 1073898 | 400.5469 | **☑** |
| n10000/R01000/s055.kp | 1391082 | 1083777 | 417.2656 | **☑** |
| n10000/R10000/s055.kp | 14073778 | 10946344 | 420.1406 | **□** |
| **08**  **Spanner**  **Weakly**  **Correlated**  **2780.468825s** | n00050/R10000/s002.kp | 24490 | 133455 | 0.015625 | **☑** |
| n00100/R10000/s003.kp | 204450 | 101164 | 244.1563 | **☑** |
| n00200/R10000/s005.kp | 773220 | 330260 | 224.9531 | **☑** |
| n00500/R10000/s008.kp | 1136213 | 751846 | 312.3281 | **☑** |
| n00500/R01000/s008.kp | 113124 | 74559 | 0 | **☑** |
| n01000/R01000/s013.kp | 346266 | 113102 | 341.8594 | **☑** |
| n02000/R01000/s021.kp | 565946 | 207790 | 395.9844 | **☑** |
| n05000/R01000/s034.kp | 1798709 | 690707 | 420.125 | **□** |
| n10000/R01000/s055.kp | 2157287 | 1273354 | 420.75 | **□** |
| n10000/R10000/s055.kp | 21333062 | 12814882 | 420.2969 | **□** |
| **09**  **Spanner**  **Strongly**  **Correlated**  **2977.0627s** | n00050/R10000/s002.kp | 286794 | 132794 | 186.6563 | **☑** |
| n00100/R10000/s003.kp | 500196 | 101196 | 216.5 | **☑** |
| n00200/R10000/s005.kp | 904284 | 330284 | 233.3438 | **☑** |
| n00500/R10000/s008.kp | 2671156 | 753156 | 270.9844 | **☑** |
| n00500/R01000/s008.kp | 266820 | 74620 | 269.1719 | **☑** |
| n01000/R01000/s013.kp | 471402 | 113102 | 267.9688 | **☑** |
| n02000/R01000/s021.kp | 961523 | 207523 | 337.4375 | **☑** |
| n05000/R01000/s034.kp | 2126719 | 690919 | 354.3125 | **☑** |
| n10000/R01000/s055.kp | 5237292 | 1273392 | 420.3281 | **□** |
| n10000/R10000/s055.kp | 52428254 | 12815254 | 420.3594 | **□** |
| **10**  **Multiple**  **Strongly**  **Correlated**  **2481.922s** | n00050/R10000/s002.kp | 213558 | 135558 | 0 | **☑** |
| n00100/R10000/s003.kp | 419912 | 267912 | 0.0625 | **☑** |
| n00200/R10000/s005.kp | 832610 | 530610 | 417.7031 | **☑** |
| n00500/R10000/s008.kp | 2043422 | 1282422 | 289.0313 | **☑** |
| n00500/R01000/s008.kp | 205452 | 128352 | 221.25 | **☑** |
| n01000/R01000/s013.kp | 399592 | 243192 | 224.6563 | **☑** |
| n02000/R01000/s021.kp | 806389 | 497389 | 262.2813 | **☑** |
| n05000/R01000/s034.kp | 2009134 | 1232334 | 415.5156 | **☑** |
| n10000/R01000/s055.kp | 4025108 | 2479608 | 230.9844 | **☑** |
| n10000/R10000/s055.kp | 40261190 | 24772190 | 420.4375 | **□** |
| **11**  **Profit**  **Ceiling**  **2567.9377s** | n00050/R10000/s002.kp | 135603 | 135606 | 0 | **☑** |
| n00100/R10000/s003.kp | 267894 | 267911 | 167.5313 | **☑** |
| n00200/R10000/s005.kp | 530589 | 530611 | 224.7813 | **☑** |
| n00500/R10000/s008.kp | 1282380 | 1282424 | 188.4844 | **☑** |
| n00500/R01000/s008.kp | 128319 | 128354 | 114.2969 | **☑** |
| n01000/R01000/s013.kp | 243129 | 243196 | 214.5625 | **☑** |
| n02000/R01000/s021.kp | 497220 | 497412 | 397.6719 | **☑** |
| n05000/R01000/s034.kp | 1231875 | 1232332 | 420.1094 | **□** |
| n10000/R01000/s055.kp | 2478696 | 2479610 | 420.25 | **□** |
| n10000/R10000/s055.kp | 24773124 | 24774073 | 420.25 | **□** |
| **12Circle**  **3104.85965s** | n00050/R10000/s002.kp | 9040009 | 135607 | 3.8125 | **☑** |
| n00100/R10000/s003.kp | 17859964 | 267913 | 328.4063 | **☑** |
| n00200/R10000/s005.kp | 35372412 | 530613 | 0.03125 | **☑** |
| n00500/R10000/s008.kp | 85490739 | 1282426 | 365.2969 | **☑** |
| n00500/R01000/s008.kp | 2704535 | 128354 | 347.5313 | **☑** |
| n01000/R01000/s013.kp | 5124386 | 243197 | 392.2813 | **☑** |
| n02000/R01000/s021.kp | 10480972 | 497414 | 407.0625 | **☑** |
| n05000/R01000/s034.kp | 25966424 | 1232334 | 420.0469 | **□** |
| n10000/R01000/s055.kp | 52247732 | 2479611 | 420.2344 | **□** |
| n10000/R10000/s055.kp | 1651521412 | 24774074 | 420.1563 | **□** |

Dựa vào bảng thống kê trên, em tóm gọn lại kết quả và xếp các nhóm test case theo mức độ dễ tới khó, qua đó chọn ra nhóm test case dễ nhất và khó nhất.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Kết luận** | | **Nhóm Test case** | **Kết quả** | | | | |
| Thời gian | | | | Tối ưu |
| Các test case được sắp xếp theo thứ tự tăng dần của thời gian và độ khó | **DỄ** | 05 SubsetSum **(Dễ nhất)** | 0.5625s | | | | 10/10 |
| 01  WeaklyCorrelated | 0.71875s | | | | 10/10 |
| 00  Uncorrelated | 0.875s | | | | 10/10 |
| **KHÓ** | 04  AlmostStronglyCorrelated | 1519.8438s | | | | 9/10 |
| 06  UncorrelatedWithSimilarWeights | 2004.640675s | | | | 8/10 |
| 02StronglyCorrelated | 2082.172s | | | 9/10 | |
| 10  MultipleStronglyCorrelated | 2481.922s | | | 9/10 | |
| 07  SpannerUncorrelated | 2555.67193s | | | 9/10 | |
| 11  ProfitCeiling | 2567.9377s | | | 7/10 | |
| 03  InverseStronglyCorrelated | 2676.000025s | | | 8/10 | |
| 08  SpannerWeaklyCorrelated | 2780.468825s | | 7/10 | | |
| 09  SpannerStronglyCorrelated | 2977.0627s | 8/10 | | | |
| 12  Circle (**Khó nhất)** | 3104.85965s | 7/10 | | | |