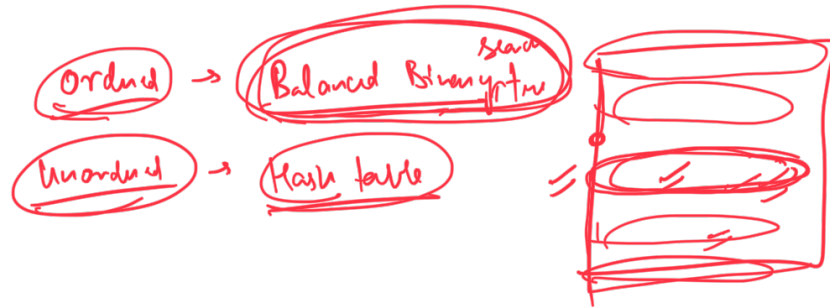


Let's start at 8:35



Set

2, 3, 3, 7, 7, 7

2, 3, 7

Set

unordered - bit

| 0   | 1   | 2   | 3   | 4    |
|-----|-----|-----|-----|------|
| 1   | 4   | 7   | 10  |      |
| 5   | 8   | 11  | 14  | 17   |
| 9   | 12  | 15  | 18  | 21   |
| 13  | 16  | 19  | 22  | 25   |
| 17  | 20  | 23  | 26  | 29   |
| 21  | 24  | 27  | 30  | 33   |
| 25  | 28  | 31  | 34  | 37   |
| 29  | 32  | 35  | 38  | 41   |
| 33  | 36  | 39  | 42  | 45   |
| 37  | 40  | 43  | 46  | 49   |
| 41  | 44  | 47  | 50  | 53   |
| 45  | 48  | 51  | 54  | 57   |
| 49  | 52  | 55  | 58  | 61   |
| 53  | 56  | 59  | 62  | 65   |
| 57  | 60  | 63  | 66  | 69   |
| 61  | 64  | 67  | 70  | 73   |
| 65  | 68  | 71  | 74  | 77   |
| 69  | 72  | 75  | 78  | 81   |
| 73  | 76  | 79  | 82  | 85   |
| 77  | 80  | 83  | 86  | 89   |
| 81  | 84  | 87  | 90  | 93   |
| 85  | 88  | 91  | 94  | 97   |
| 89  | 92  | 95  | 98  | 101  |
| 93  | 96  | 99  | 102 | 105  |
| 97  | 100 | 103 | 106 | 109  |
| 101 | 104 | 107 | 110 | 113  |
| 105 | 108 | 111 | 114 | 117  |
| 109 | 112 | 115 | 118 | 121  |
| 113 | 116 | 119 | 122 | 125  |
| 117 | 120 | 123 | 126 | 129  |
| 121 | 124 | 127 | 130 | 133  |
| 125 | 128 | 131 | 134 | 137  |
| 129 | 132 | 135 | 138 | 141  |
| 133 | 136 | 139 | 142 | 145  |
| 137 | 140 | 143 | 146 | 149  |
| 141 | 144 | 147 | 150 | 153  |
| 145 | 148 | 151 | 154 | 157  |
| 149 | 152 | 155 | 158 | 161  |
| 153 | 156 | 159 | 162 | 165  |
| 157 | 160 | 163 | 166 | 169  |
| 161 | 164 | 167 | 170 | 173  |
| 165 | 168 | 171 | 174 | 177  |
| 169 | 172 | 175 | 178 | 181  |
| 173 | 176 | 179 | 182 | 185  |
| 177 | 180 | 183 | 186 | 189  |
| 181 | 184 | 187 | 190 | 193  |
| 185 | 188 | 191 | 194 | 197  |
| 189 | 192 | 195 | 198 | 201  |
| 193 | 196 | 199 | 202 | 205  |
| 197 | 200 | 203 | 206 | 209  |
| 201 | 204 | 207 | 210 | 213  |
| 205 | 208 | 211 | 214 | 217  |
| 209 | 212 | 215 | 218 | 221  |
| 213 | 216 | 219 | 222 | 225  |
| 217 | 220 | 223 | 226 | 229  |
| 221 | 224 | 227 | 230 | 233  |
| 225 | 228 | 231 | 234 | 237  |
| 229 | 232 | 235 | 238 | 241  |
| 233 | 236 | 239 | 242 | 245  |
| 237 | 240 | 243 | 246 | 249  |
| 241 | 244 | 247 | 250 | 253  |
| 245 | 248 | 251 | 254 | 257  |
| 249 | 252 | 255 | 258 | 261  |
| 253 | 256 | 259 | 262 | 265  |
| 257 | 260 | 263 | 266 | 269  |
| 261 | 264 | 267 | 270 | 273  |
| 265 | 268 | 271 | 274 | 277  |
| 269 | 272 | 275 | 278 | 281  |
| 273 | 276 | 279 | 282 | 285  |
| 277 | 280 | 283 | 286 | 289  |
| 281 | 284 | 287 | 290 | 293  |
| 285 | 288 | 291 | 294 | 297  |
| 289 | 292 | 295 | 298 | 301  |
| 293 | 296 | 299 | 302 | 305  |
| 297 | 300 | 303 | 306 | 309  |
| 301 | 304 | 307 | 310 | 313  |
| 305 | 308 | 311 | 314 | 317  |
| 309 | 312 | 315 | 318 | 321  |
| 313 | 316 | 319 | 322 | 325  |
| 317 | 320 | 323 | 326 | 329  |
| 321 | 324 | 327 | 330 | 333  |
| 325 | 328 | 331 | 334 | 337  |
| 329 | 332 | 335 | 338 | 341  |
| 333 | 336 | 339 | 342 | 345  |
| 337 | 340 | 343 | 346 | 349  |
| 341 | 344 | 347 | 350 | 353  |
| 345 | 348 | 351 | 354 | 357  |
| 349 | 352 | 355 | 358 | 361  |
| 353 | 356 | 359 | 362 | 365  |
| 357 | 360 | 363 | 366 | 369  |
| 361 | 364 | 367 | 370 | 373  |
| 365 | 368 | 371 | 374 | 377  |
| 369 | 372 | 375 | 378 | 381  |
| 373 | 376 | 379 | 382 | 385  |
| 377 | 380 | 383 | 386 | 389  |
| 381 | 384 | 387 | 390 | 393  |
| 385 | 388 | 391 | 394 | 397  |
| 389 | 392 | 395 | 398 | 401  |
| 393 | 396 | 399 | 402 | 405  |
| 397 | 400 | 403 | 406 | 409  |
| 401 | 404 | 407 | 410 | 413  |
| 405 | 408 | 411 | 414 | 417  |
| 409 | 412 | 415 | 418 | 421  |
| 413 | 416 | 419 | 422 | 425  |
| 417 | 420 | 423 | 426 | 429  |
| 421 | 424 | 427 | 430 | 433  |
| 425 | 428 | 431 | 434 | 437  |
| 429 | 432 | 435 | 438 | 441  |
| 433 | 436 | 439 | 442 | 445  |
| 437 | 440 | 443 | 446 | 449  |
| 441 | 444 | 447 | 450 | 453  |
| 445 | 448 | 451 | 454 | 457  |
| 449 | 452 | 455 | 458 | 461  |
| 453 | 456 | 459 | 462 | 465  |
| 457 | 460 | 463 | 466 | 469  |
| 461 | 464 | 467 | 470 | 473  |
| 465 | 468 | 471 | 474 | 477  |
| 469 | 472 | 475 | 478 | 481  |
| 473 | 476 | 479 | 482 | 485  |
| 477 | 480 | 483 | 486 | 489  |
| 481 | 484 | 487 | 490 | 493  |
| 485 | 488 | 491 | 494 | 497  |
| 489 | 492 | 495 | 498 | 501  |
| 493 | 496 | 499 | 502 | 505  |
| 497 | 500 | 503 | 506 | 509  |
| 501 | 504 | 507 | 510 | 513  |
| 505 | 508 | 511 | 514 | 517  |
| 509 | 512 | 515 | 518 | 521  |
| 513 | 516 | 519 | 522 | 525  |
| 517 | 520 | 523 | 526 | 529  |
| 521 | 524 | 527 | 530 | 533  |
| 525 | 528 | 531 | 534 | 537  |
| 529 | 532 | 535 | 538 | 541  |
| 533 | 536 | 539 | 542 | 545  |
| 537 | 540 | 543 | 546 | 549  |
| 541 | 544 | 547 | 550 | 553  |
| 545 | 548 | 551 | 554 | 557  |
| 549 | 552 | 555 | 558 | 561  |
| 553 | 556 | 559 | 562 | 565  |
| 557 | 560 | 563 | 566 | 569  |
| 561 | 564 | 567 | 570 | 573  |
| 565 | 568 | 571 | 574 | 577  |
| 569 | 572 | 575 | 578 | 581  |
| 573 | 576 | 579 | 582 | 585  |
| 577 | 580 | 583 | 586 | 589  |
| 581 | 584 | 587 | 590 | 593  |
| 585 | 588 | 591 | 594 | 597  |
| 589 | 592 | 595 | 598 | 601  |
| 593 | 596 | 599 | 602 | 605  |
| 597 | 600 | 603 | 606 | 609  |
| 601 | 604 | 607 | 610 | 613  |
| 605 | 608 | 611 | 614 | 617  |
| 609 | 612 | 615 | 618 | 621  |
| 613 | 616 | 619 | 622 | 625  |
| 617 | 620 | 623 | 626 | 629  |
| 621 | 624 | 627 | 630 | 633  |
| 625 | 628 | 631 | 634 | 637  |
| 629 | 632 | 635 | 638 | 641  |
| 633 | 636 | 639 | 642 | 645  |
| 637 | 640 | 643 | 646 | 649  |
| 641 | 644 | 647 | 650 | 653  |
| 645 | 648 | 651 | 654 | 657  |
| 649 | 652 | 655 | 658 | 661  |
| 653 | 656 | 659 | 662 | 665  |
| 657 | 660 | 663 | 666 | 669  |
| 661 | 664 | 667 | 670 | 673  |
| 665 | 668 | 671 | 674 | 677  |
| 669 | 672 | 675 | 678 | 681  |
| 673 | 676 | 679 | 682 | 685  |
| 677 | 680 | 683 | 686 | 689  |
| 681 | 684 | 687 | 690 | 693  |
| 685 | 688 | 691 | 694 | 697  |
| 689 | 692 | 695 | 698 | 701  |
| 693 | 696 | 699 | 702 | 705  |
| 697 | 700 | 703 | 706 | 709  |
| 701 | 704 | 707 | 710 | 713  |
| 705 | 708 | 711 | 714 | 717  |
| 709 | 712 | 715 | 718 | 721  |
| 713 | 716 | 719 | 722 | 725  |
| 717 | 720 | 723 | 726 | 729  |
| 721 | 724 | 727 | 730 | 733  |
| 725 | 728 | 731 | 734 | 737  |
| 729 | 732 | 735 | 738 | 741  |
| 733 | 736 | 739 | 742 | 745  |
| 737 | 740 | 743 | 746 | 749  |
| 741 | 744 | 747 | 750 | 753  |
| 745 | 748 | 751 | 754 | 757  |
| 749 | 752 | 755 | 758 | 761  |
| 753 | 756 | 759 | 762 | 765  |
| 757 | 760 | 763 | 766 | 769  |
| 761 | 764 | 767 | 770 | 773  |
| 765 | 768 | 771 | 774 | 777  |
| 769 | 772 | 775 | 778 | 781  |
| 773 | 776 | 779 | 782 | 785  |
| 777 | 780 | 783 | 786 | 789  |
| 781 | 784 | 787 | 790 | 793  |
| 785 | 788 | 791 | 794 | 797  |
| 789 | 792 | 795 | 798 | 801  |
| 793 | 796 | 799 | 802 | 805  |
| 797 | 800 | 803 | 806 | 809  |
| 801 | 804 | 807 | 810 | 813  |
| 805 | 808 | 811 | 814 | 817  |
| 809 | 812 | 815 | 818 | 821  |
| 813 | 816 | 819 | 822 | 825  |
| 817 | 820 | 823 | 826 | 829  |
| 821 | 824 | 827 | 830 | 833  |
| 825 | 828 | 831 | 834 | 837  |
| 829 | 832 | 835 | 838 | 841  |
| 833 | 836 | 839 | 842 | 845  |
| 837 | 840 | 843 | 846 | 849  |
| 841 | 844 | 847 | 850 | 853  |
| 845 | 848 | 851 | 854 | 857  |
| 849 | 852 | 855 | 858 | 861  |
| 853 | 856 | 859 | 862 | 865  |
| 857 | 860 | 863 | 866 | 869  |
| 861 | 864 | 867 | 870 | 873  |
| 865 | 868 | 871 | 874 | 877  |
| 869 | 872 | 875 | 878 | 881  |
| 873 | 876 | 879 | 882 | 885  |
| 877 | 880 | 883 | 886 | 889  |
| 881 | 884 | 887 | 890 | 893  |
| 885 | 888 | 891 | 894 | 897  |
| 889 | 892 | 895 | 898 | 901  |
| 893 | 896 | 899 | 902 | 905  |
| 897 | 900 | 903 | 906 | 909  |
| 901 | 904 | 907 | 910 | 913  |
| 905 | 908 | 911 | 914 | 917  |
| 909 | 912 | 915 | 918 | 921  |
| 913 | 916 | 919 | 922 | 925  |
| 917 | 920 | 923 | 926 | 929  |
| 921 | 924 | 927 | 930 | 933  |
| 925 | 928 | 931 | 934 | 937  |
| 929 | 932 | 935 | 938 | 941  |
| 933 | 936 | 939 | 942 | 945  |
| 937 | 940 | 943 | 946 | 949  |
| 941 | 944 | 947 | 950 | 953  |
| 945 | 948 | 951 | 954 | 957  |
| 949 | 952 | 955 | 958 | 961  |
| 953 | 956 | 959 | 962 | 965  |
| 957 | 960 | 963 | 966 | 969  |
| 961 | 964 | 967 | 970 | 973  |
| 965 | 968 | 971 | 974 | 977  |
| 969 | 972 | 975 | 978 | 981  |
| 973 | 976 | 979 | 982 | 985  |
| 977 | 980 | 983 | 986 | 989  |
| 981 | 984 | 987 | 990 | 993  |
| 985 | 988 | 991 | 994 | 997  |
| 989 | 992 | 995 | 998 | 1001 |

Matrix

Searching

Lower bound of any particular

Upper bound of any particular

Binary search

m x n

log(n) time

O(1)

Space

log log

O(m, n)

(m x n)

1

50

100

max

row index

|   | 1  | 2  | 3  | 4    |
|---|----|----|----|------|
| 1 | 4  | 7  | 10 | 10.5 |
| 2 | 6  | 7  | 8  | 9    |
| 3 | 15 | 17 | 21 | 27   |
| 4 | 31 | 39 | 43 | 44   |
| 5 | 48 | 51 | 55 | 56   |

11

28

46

34

0

1

row-1

$$\log(\text{rows}) + \log(\text{column})$$

$$\log(\text{rows} \times \text{column})$$

row, column

Binary

low

upper

mid

row =  $\frac{\text{mid}}{\text{column}}$  ✓

column =  $\frac{\text{mid}}{\text{row}}$  ✓

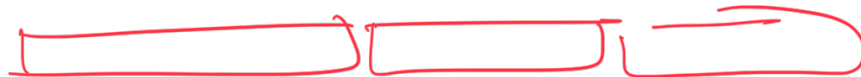




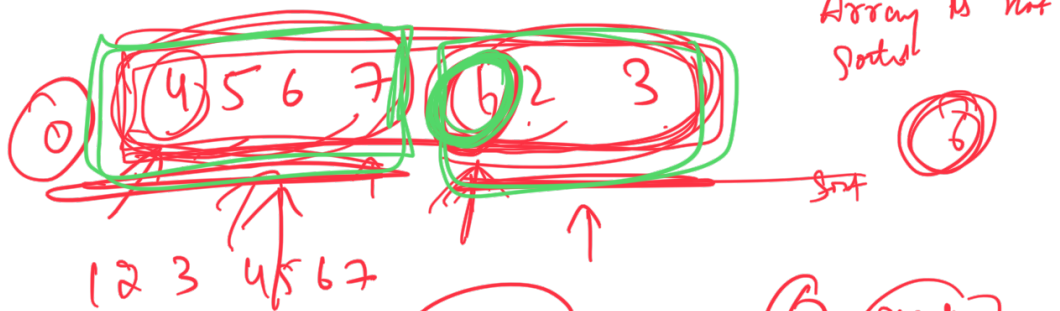
an  
↑

an + m n

ans



Interactive



1 2 3 4 5 6 7

0 log n

element

0

0 log n

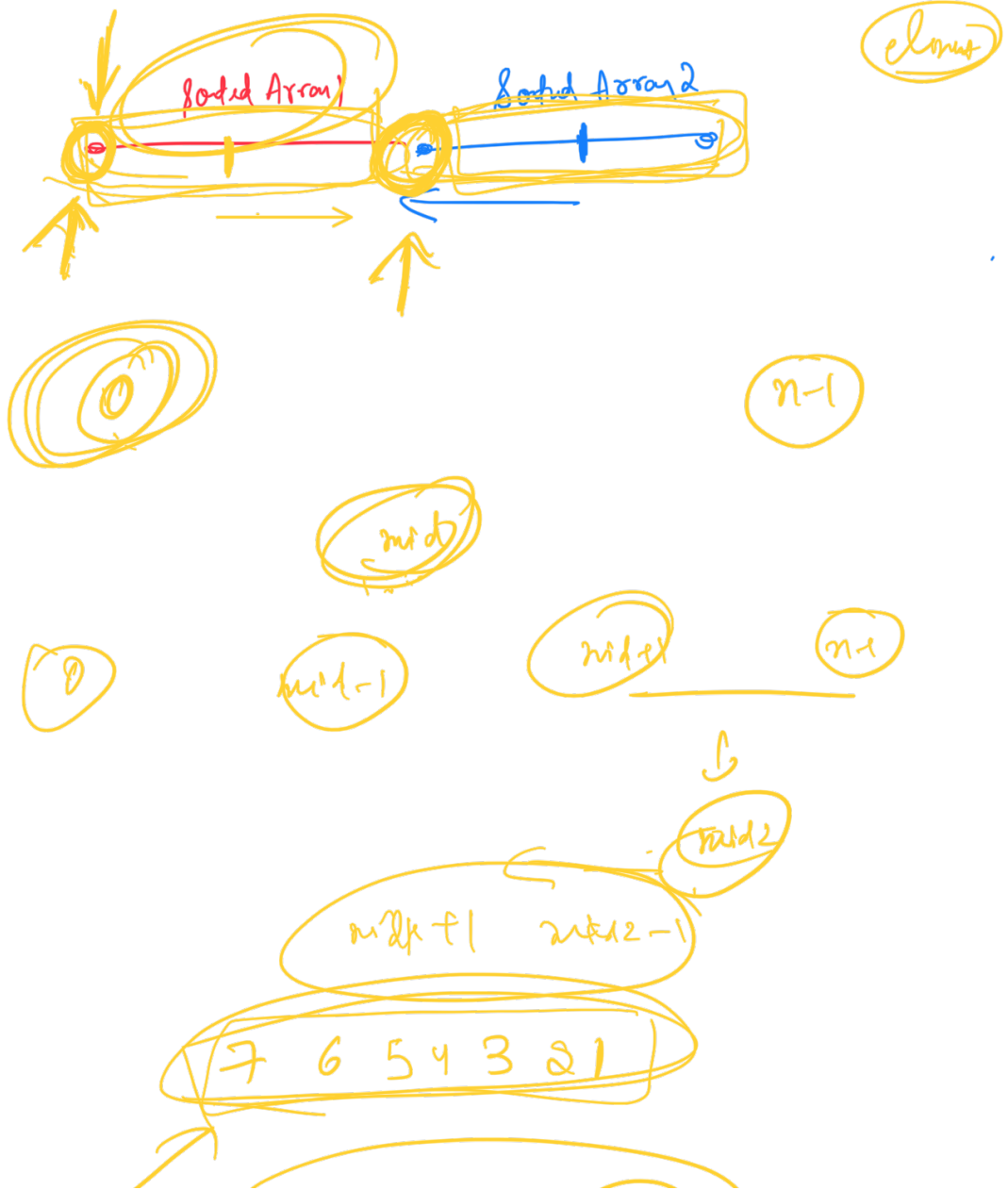
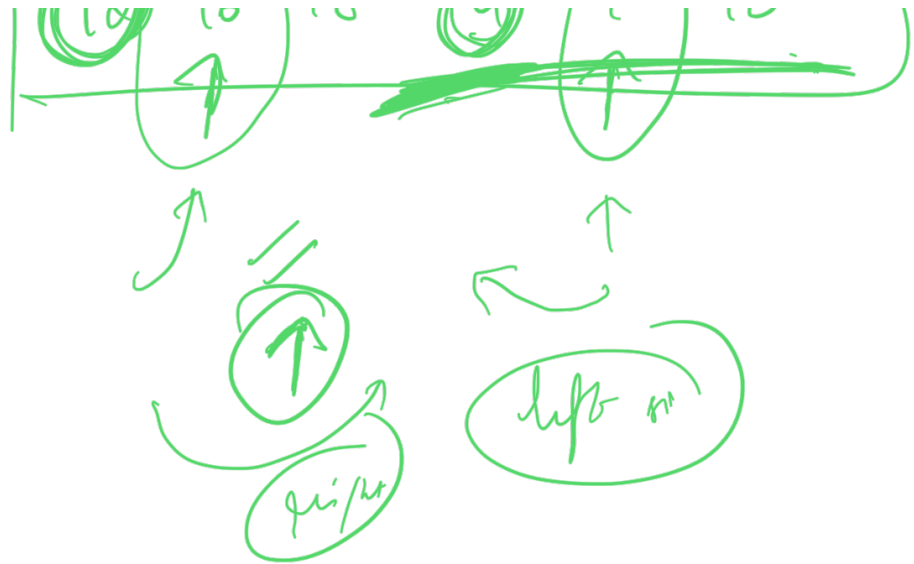
0



→ Minimum for element

then low or down





(1 2 3 4 5 (6 7))

6 7 1 2 3 4 5 6 7

[ ] [ ]

1 2 3 4 5 (6 7)

6 7 1 2 3 4 5

1614 Interactive Questions

0 0 0 0 0 0  
Information ↑

In min possible queries

l n

46-50

Mar

↑

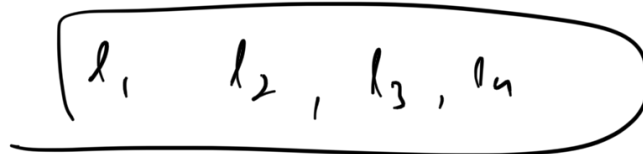
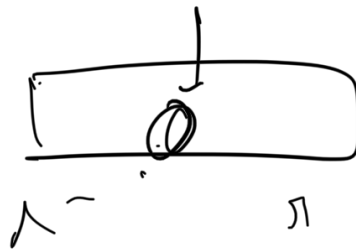
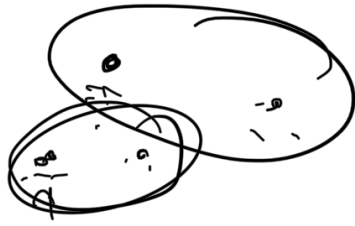
1 2 1 7 6 4 3  
0 1 2 3 4 5 6

0, 6

↑

2 2 2

↙ ↘

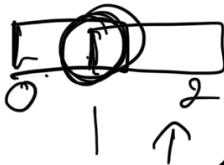


⑥

1 is

⑩

↑

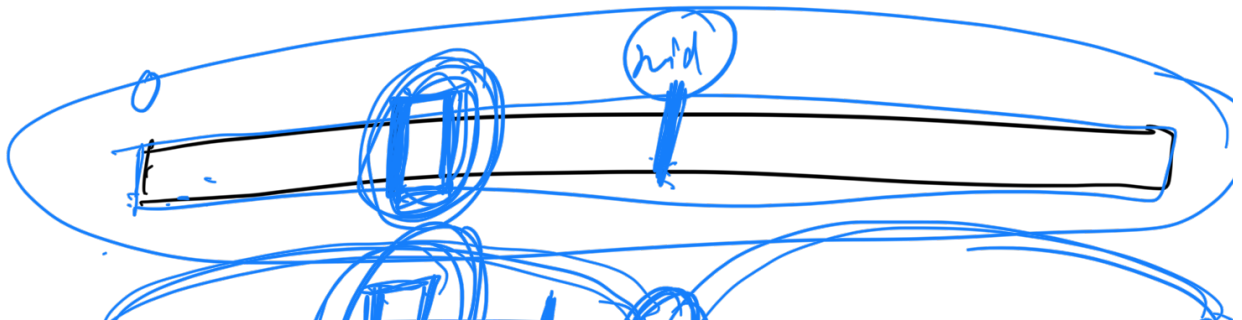


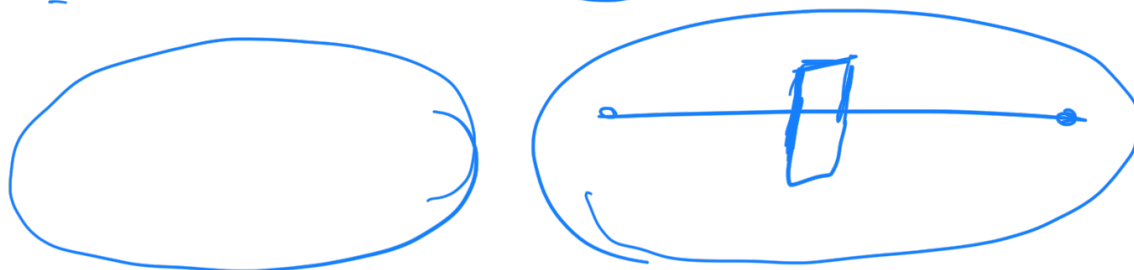
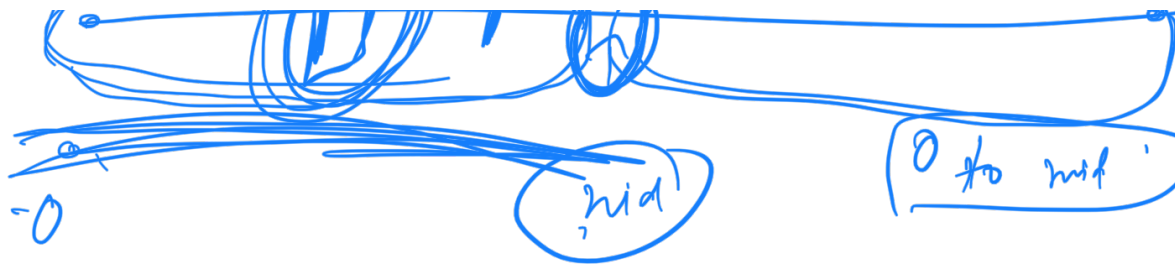
1 > 0

⑥

2 > 1

①





$$\log(10^{18}) \leq 40$$

Gig



start mid

mid end

