

23/9/2020

Calculation :

FLAT - Unit II

RegEx:-

Operators of regular expression:-

→ Operations on languages:-

1) Union of languages:-

$L, M \rightarrow 2$ languages

$L \cup M \rightarrow$ set of strings in either L or M or both.

Ex:-

$$L = \{00, 11, \epsilon\}$$

$$M = \{01, 111\}$$

$$L \cup M = \{00, 01, 111\}$$

$$L \cup M = \{00, 01, \epsilon, 01, 111\}$$

2) Concatenation of languages :-

$$L = \{0, 11\} \quad M = \{\epsilon, 00, 11\}$$

$$L \cdot M \text{ or } LM = \{0, 000, 011, 11, 1100, 1111\}$$

3) Closure of a language (star or kleene closure) :-

$L \rightarrow$ Language, $L^* \rightarrow$ Closure of L

$L = \{0, 1\}$ $L^* \Rightarrow$ set of all strings of any length containing 0's, 1's

$$\text{Ex: } L^* = \{\epsilon, 0, 1, 00, 01, 11, 000, 0111, \dots\}$$

$$L^* = L^0 \cup L^1 \cup L^2 \cup \dots$$

$$L^1 = L$$

$$L^2 = L \cdot L$$

$$L^3 = L^2 \cdot L$$

⋮

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DEPARTMENT OF PHYSICS

Expt. No. _____

Date _____

Title of Experiment _____

Aim: Building Regular Expressions:-

• Basis:-

a) E, ϕ denote $\{E\}, \phi$

Apparatus : b) ω is any symbol, then it denotes $\{\omega\}$ (Language $L=\{\omega\}$)
c) A is a variable, used to denote language (like L), but
in complex regen's, A is also used as symbol.

Formula with S. I. unit :

• Induction:-

a) If E & F are regular expressions, then so is $E+F$.

$E+F$ denotes $L(E) \cup L(F)$. $L(E+F) = L(E) \cup L(F)$.

b) If E & F are regular expressions, then so is $E.F$.

Principle : $E.F$ or EF denotes $L(E).L(F)$. $L(E.F) = L(E).L(F)$

c) If E is a regen, then E^* is also a regen denoting
closure of $L(E)$. $L(E^*) = (L(E))^*$.

d) If E is a regen, (E) is also a regen denoting the same language
as that of E . $L((E)) = L(E)$.

Regen closely matches with NFA, because for a given problem
we can have many NFA's & Regen's, but limited DFA's.

Diagram :

Precedence of operators:-

1) *

2) .

3) +

Examples:-

Observation : Write a RE for any number of a's.

Ans) a^*

Write a RE for a or b.

Ans) $a+b$ or $(a+b)$

Write a RE for any no's of a's & b's.

Ans) $(a+b)^*$

Write a RE for the sequence 01.

Ans) $0 \cdot 1$ or 01

Write a RE for any ^{no. of} 0's followed by any ^{no. of} 1's.

Ans) $0^* \cdot 1^*$ or $0^* 1^*$

Write a RE for 0101010101.....

Ans) $(01)^*$

Write or RE for sequence of a's & b's such that the last symbol is a.

Ans) $(a+b)^* \cdot a$ or $(a+b)^* a$

Write or RE for the strings of a's & b's such that the substring ab is present.

Ans) $(a+b)^* ab(a+b)^*$

Write or RE for $\Sigma = \{a, b\}$ such that strings end with ab.

Ans) $(a+b)^* ab$

Beginning with ab.

Ans) ~~a~~ ab(a+b)*

Beginning or ends with ab.

Ans) $(a+b)^* ab + ab(a+b)^*$

RE for even number of a's.

Ans) $(aa)^*$

RE for ~~a^*~~ whose length is 2, $\Sigma = \{a, b\}$

Ans) $(a+b)(a+b)$

Result :

Calculation :

RE for odd length, $\Sigma = \{a\}$
Ans) $a(aaa)*$ or $(aaa)*a$

| Sum | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 | 125 | 126 | 127 | 128 | 129 | 130 | 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 | 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 | 151 | 152 | 153 | 154 | 155 | 156 | 157 | 158 | 159 | 160 | 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 | 181 | 182 | 183 | 184 | 185 | 186 | 187 | 188 | 189 | 190 | 191 | 192 | 193 | 194 | 195 | 196 | 197 | 198 | 199 | 200 | 201 | 202 | 203 | 204 | 205 | 206 | 207 | 208 | 209 | 210 | 211 | 212 | 213 | 214 | 215 | 216 | 217 | 218 | 219 | 220 | 221 | 222 | 223 | 224 | 225 | 226 | 227 | 228 | 229 | 230 | 231 | 232 | 233 | 234 | 235 | 236 | 237 | 238 | 239 | 240 | 241 | 242 | 243 | 244 | 245 | 246 | 247 | 248 | 249 | 250 | 251 | 252 | 253 | 254 | 255 | 256 | 257 | 258 | 259 | 260 | 261 | 262 | 263 | 264 | 265 | 266 | 267 | 268 | 269 | 270 | 271 | 272 | 273 | 274 | 275 | 276 | 277 | 278 | 279 | 280 | 281 | 282 | 283 | 284 | 285 | 286 | 287 | 288 | 289 | 290 | 291 | 292 | 293 | 294 | 295 | 296 | 297 | 298 | 299 | 300 | 301 | 302 | 303 | 304 | 305 | 306 | 307 | 308 | 309 | 310 | 311 | 312 | 313 | 314 | 315 | 316 | 317 | 318 | 319 | 320 | 321 | 322 | 323 | 324 | 325 | 326 | 327 | 328 | 329 | 330 | 331 | 332 | 333 | 334 | 335 | 336 | 337 | 338 | 339 | 340 | 341 | 342 | 343 | 344 | 345 | 346 | 347 | 348 | 349 | 350 | 351 | 352 | 353 | 354 | 355 | 356 | 357 | 358 | 359 | 360 | 361 | 362 | 363 | 364 | 365 | 366 | 367 | 368 | 369 | 370 | 371 | 372 | 373 | 374 | 375 | 376 | 377 | 378 | 379 | 380 | 381 | 382 | 383 | 384 | 385 | 386 | 387 | 388 | 389 | 390 | 391 | 392 | 393 | 394 | 395 | 396 | 397 | 398 | 399 | 400 | 401 | 402 | 403 | 404 | 405 | 406 | 407 | 408 | 409 | 410 | 411 | 412 | 413 | 414 | 415 | 416 | 417 | 418 | 419 | 420 | 421 | 422 | 423 | 424 | 425 | 426 | 427 | 428 | 429 | 430 | 431 | 432 | 433 | 434 | 435 | 436 | 437 | 438 | 439 | 440 | 441 | 442 | 443 | 444 | 445 | 446 | 447 | 448 | 449 | 450 | 451 | 452 | 453 | 454 | 455 | 456 | 457 | 458 | 459 | 460 | 461 | 462 | 463 | 464 | 465 | 466 | 467 | 468 | 469 | 470 | 471 | 472 | 473 | 474 | 475 | 476 | 477 | 478 | 479 | 480 | 481 | 482 | 483 | 484 | 485 | 486 | 487 | 488 | 489 | 490 | 491 | 492 | 493 | 494 | 495 | 496 | 497 | 498 | 499 | 500 | 501 | 502 | 503 | 504 | 505 | 506 | 507 | 508 | 509 | 510 | 511 | 512 | 513 | 514 | 515 | 516 | 517 | 518 | 519 | 520 | 521 | 522 | 523 | 524 | 525 | 526 | 527 | 528 | 529 | 530 | 531 | 532 | 533 | 534 | 535 | 536 | 537 | 538 | 539 | 540 | 541 | 542 | 543 | 544 | 545 | 546 | 547 | 548 | 549 | 550 | 551 | 552 | 553 | 554 | 555 | 556 | 557 | 558 | 559 | 560 | 561 | 562 | 563 | 564 | 565 | 566 | 567 | 568 | 569 | 570 | 571 | 572 | 573 | 574 | 575 | 576 | 577 | 578 | 579 | 580 | 581 | 582 | 583 | 584 | 585 | 586 | 587 | 588 | 589 | 590 | 591 | 592 | 593 | 594 | 595 | 596 | 597 | 598 | 599 | 600 | 601 | 602 | 603 | 604 | 605 | 606 | 607 | 608 | 609 | 610 | 611 | 612 | 613 | 614 | 615 | 616 | 617 | 618 | 619 | 620 | 621 | 622 | 623 | 624 | 625 | 626 | 627 | 628 | 629 | 630 | 631 | 632 | 633 | 634 | 635 | 636 | 637 | 638 | 639 | 640 | 641 | 642 | 643 | 644 | 645 | 646 | 647 | 648 | 649 | 650 | 651 | 652 | 653 | 654 | 655 | 656 | 657 | 658 | 659 | 660 | 661 | 662 | 663 | 664 | 665 | 666 | 667 | 668 | 669 | 670 | 671 | 672 | 673 | 674 | 675 | 676 | 677 | 678 | 679 | 680 | 681 | 682 | 683 | 684 | 685 | 686 | 687 | 688 | 689 | 690 | 691 | 692 | 693 | 694 | 695 | 696 | 697 | 698 | 699 | 700 | 701 | 702 | 703 | 704 | 705 | 706 | 707 | 708 | 709 | 710 | 711 | 712 | 713 | 714 | 715 | 716 | 717 | 718 | 719 | 720 | 721 | 722 | 723 | 724 | 725 | 726 | 727 | 728 | 729 | 730 | 731 | 732 | 733 | 734 | 735 | 736 | 737 | 738 | 739 | 740 | 741 | 742 | 743 | 744 | 745 | 746 | 747 | 748 | 749 | 750 | 751 | 752 | 753 | 754 | 755 | 756 | 757 | 758 | 759 | 760 | 761 | 762 | 763 | 764 | 765 | 766 | 767 | 768 | 769 | 770 | 771 | 772 | 773 | 774 | 775 | 776 | 777 | 778 | 779 | 780 | 781 | 782 | 783 | 784 | 785 | 786 | 787 | 788 | 789 | 790 | 791 | 792 | 793 | 794 | 795 | 796 | 797 | 798 | 799 | 800 | 801 | 802 | 803 | 804 | 805 | 806 | 807 | 808 | 809 | 810 | 811 | 812 | 813 | 814 | 815 | 816 | 817 | 818 | 819 | 820 | 821 | 822 | 823 | 824 | 825 | 826 | 827 | 828 | 829 | 830 | 831 | 832 | 833 | 834 | 835 | 836 | 837 | 838 | 839 | 840 | 841 | 842 | 843 | 844 | 845 | 846 | 847 | 848 | 849 | 850 | 851 | 852 | 853 | 854 | 855 | 856 | 857 | 858 | 859 | 860 | 861 | 862 | 863 | 864 | 865 | 866 | 867 | 868 | 869 | 870 | 871 | 872 | 873 | 874 | 875 | 876 | 877 | 878 | 879 | 880 | 881 | 882 | 883 | 884 | 885 | 886 | 887 | 888 | 889 | 890 | 891 | 892 | 893 | 894 | 895 | 896 | 897 | 898 | 899 | 900 | 901 | 902 | 903 | 904 | 905 | 906 | 907 | 908 | 909 | 910 | 911 | 912 | 913 | 914 | 915 | 916 | 917 | 918 | 919 | 920 | 921 | 922 | 923 | 924 | 925 | 926 | 927 | 928 | 929 | 930 | 931 | 932 | 933 | 934 | 935 | 936 | 937 | 938 | 939 | 940 | 941 | 942 | 943 | 944 | 945 | 946 | 947 | 948 | 949 | 950 | 951 | 952 | 953 | 954 | 955 | 956 | 957 | 958 | 959 | 960 | 961 | 962 | 963 | 964 | 965 | 966 | 967 | 968 | 969 | 970 | 971 | 972 | 973 | 974 | 975 | 976 | 977 | 978 | 979 | 980 | 981 | 982 | 983 | 984 | 985 | 986 | 987 | 988 | 989 | 990 | 991 | 992 | 993 | 994 | 995 | 996 | 997 | 998 | 999 | 1000 | 1001 | 1002 | 1003 | 1004 | 1005 | 1006 | 1007 | 1008 | 1009 | 1010 | 1011 | 1012 | 1013 | 1014 | 1015 | 1016 | 1017 | 1018 | 1019 | 1020 | 1021 | 1022 | 1023 | 1024 | 1025 | 1026 | 1027 | 1028 | 1029 | 1030 | 1031 | 1032 | 1033 | 1034 | 1035 | 1036 | 1037 | 1038 | 1039 | 1040 | 1041 | 1042 | 1043 | 1044 | 1045 | 1046 | 1047 | 1048 | 1049 | 1050 | 1051 | 1052 | 1053 | 1054 | 1055 | 1056 | 1057 | 1058 | 1059 | 1060 | 1061 | 1062 | 1063 | 1064 | 1065 | 1066 | 1067 | 1068 | 1069 | 1070 | 1071 | 1072 | 1073 | 1074 | 1075 | 1076 | 1077 | 1078 | 1079 | 1080 | 1081 | 1082 | 1083 | 1084 | 1085 | 1086 | 1087 | 1088 | 1089 | 1090 | 1091 | 1092 | 1093 | 1094 | 1095 | 1096 | 1097 | 1098 | 1099 | 1100 | 1101 | 1102 | 1103 | 1104 | 1105 | 1106 | 1107 | 1108 | 1109 | 1110 | 1111 | 1112 | 1113 | 1114 | 1115 | 1116 | 1117 | 1118 | 1119 | 1120 | 1121 | 1122 | 1123 | 1124 | 1125 | 1126 | 1127 | 1128 | 1129 | 1130 | 1131 | 1132 | 1133 | 1134 | 1135 | 1136 | 1137 | 1138 | 1139 | 1140 | 1141 | 1142 | 1143 | 1144 | 1145 | 1146 | 1147 | 1148 | 1149 | 1150 | 1151 | 1152 | 1153 | 1154 | 1155 | 1156 | 1157 | 1158 | 1159 | 1160 | 1161 | 1162 | 1163 | 1164 | 1165 | 1166 | 1167 | 1168 | 1169 | 1170 | 1171 | 1172 | 1173 | 1174 | 1175 | 1176 | 1177 | 1178 | 1179 | 1180 | 1181 | 1182 | 1183 | 1184 | 1185 | 1186 | 1187 | 1188 | 1189 | 1190 | 1191 | 1192 | 1193 | 1194 | 1195 | 1196 | 1197 | 1198 | 1199 | 1200 | 1201 | 1202 | 1203 | 1204 | 1205 | 1206 | 1207 | 1208 | 1209 | 1210 | 1211 | 1212 | 1213 | 1214 | 1215 | 1216 | 1217 | 1218 | 1219 | 1220 | 1221 | 1222 | 1223 | 1224 | 1225 | 1226 | 1227 | 1228 | 1229 | 1230 | 1231 | 1232 | 1233 | 1234 | 1235 | 1236 | 1237 | 1238 | 1239 | 1240 | 1241 | 1242 | 1243 | 1244 | 1245 | 1246 | 1247 | 1248 | 1249 | 1250 | 1251 | 1252 | 1253 | 1254 | 1255 | 1256 | 1257 | 1258 | 1259 | 1260 | 1261 | 1262 | 1263 | 1264 | 1265 | 1266 | 1267 | 1268 | 1269 | 1270 | 1271 | 1272 | 1273 | 1274 | 1275 | 1276 | 1277 | 1278 | 1279 | 1280 | 1281 | 1282 | 1283 | 1284 | 1285 | 1286 | 1287 | 1288 | 1289 | 1290 | 1291 | 1292 | 1293 | 1294 | 1295 | 1296 | 1297 | 1298 | 1299 | 1300 | 1301 | 1302 | 1303 | 1304 | 1305 | 1306 | 1307 | 1308 | 1309 | 1310 | 1311 | 1312 | 1313 | 1314 | 1315 | 1316 | 1317 | 1318 | 1319 | 1320 | 1321 | 1322 | 1323 | 1324 | 1325 | 1326 | 1327 | 1328 | 1329 | 1330 | 1331 | 1332 | 1333 | 1334 | 1335 | 1336 | 1337 | 1338 | 1339 | 1340 | 1341 | 1342 | 1343 | 1344 | 1345 | 1346 | 1347 | 1348 | 1349 | 1350 | 1351 | 1352 | 1353 | 1354 | 1355 | 1356 | 1357 | 1358 | 1359 | 1360 | 1361 | 1362 | 1363 | 1364 | 1365 | 1366 | 1367 | 1368 | 1369 | 1370 | 1371 | 1372 | 1373 |<
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Aim :

RE that either ends with ω or $\omega\omega$.

$$\rightarrow (a+b) * (a+b\omega)$$

Apparatus :

RE that should not end with $\omega\omega$.

$$\rightarrow \cancel{(a+b)} \cancel{*} \cancel{a+b} (a+b) * (a+b+a+b\omega)$$

RE for $L = \{ w \mid |w| \bmod 3 = 0, w \in \{a, b\}^*\}$

Formula with S. I. unit :

$$\rightarrow ((a+b)(a+b)(a+b)) *$$

RE which has atleast 3 consecutive 0's, $\Sigma = \{0, 1\}$

$$\rightarrow (0+1) * 000 \cancel{(0+1)} *$$

Principle :

RE begins with $a\omega$ & ends with $b\omega$.

$$\rightarrow \cancel{a} \cancel{b} (a+b) * b\omega$$

RE for strings of a 's & b 's whose length is either even or multiple of 3.

$$\rightarrow ((a+b)(a+b)) * + ((a+b)(a+b)(a+b)) *$$

Diagram : RE for $L = \{a^{2n}b^{2n} / n \geq 0\}$

$\rightarrow (aa)^* (bb)^*$

RE for $L = \{a^n b^m / n \geq 1, m \leq 3\}$

$\rightarrow aaaa^* (\epsilon + b + bb + bbb)$

RE for strings of a's & b's such that a's are divisible by 3.

$\rightarrow \cancel{a^* (aaa)^* b^*} (b^* a^* b^* a^* b^* a^* b^*)^*$

Observation : RE for $L = \{a^n b^m / m+n \text{ is even}\}$

$\rightarrow (aa)^* (bb)^* + a(aaa)^* b(bb)^*$

RE for strings of a's & b's such that every block of 4

~~contains~~ consecutive symbols contain at least 2 a's, a can occur anywhere.
 $\rightarrow (aa)(a+b)(a+b) + a(a+b)a(a+b) + a(a+b)(a+b)a + (a+b)a(a+b)+(a+b)(a+b)a +$
 $+ (a+b)a(a+b)a$. (same thing as in previous brackets) *

RE for $L = \{a^n b^m / m \geq 1, n+m \geq 3\}$

$\rightarrow aaaa^* bb^* + aa^* bbbb^* + aaaa^* bbbb^*$

RE for strings of a's & b's containing not more than 3 a's.

$\rightarrow ((\epsilon + a+b)(\epsilon + a+b)(\epsilon + a+b)b^*) + ((\epsilon + a+b)(\epsilon + a+b)b^*(\epsilon + a+b)b^*)$
 $+ ((\epsilon + a+b)b^*(\epsilon + a+b)b^*(\epsilon + a+b)b^*) + (b^*(\epsilon + a+b)b^*(\epsilon + a+b)b^*(\epsilon + a+b)b^*)$

RE for $L = \{uvv / u, v \text{ belong to } \{a, b\}^* \text{ and } |v|=2\}$

$\rightarrow \cancel{a^* (a+b)^* (a+b)^* (a+b)^* (a+b)}$

$a^* a^* (a+b)^* a^* a^* + ab(a+b)^* ab + ba(a+b)^* ba + bb(a+b)^* bb$

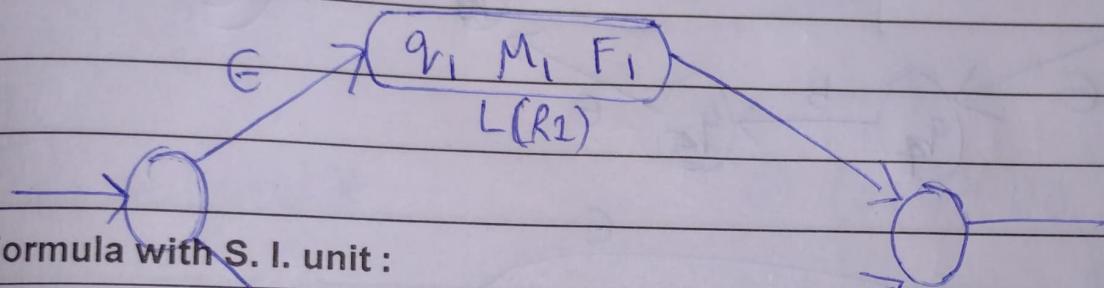
Aim : RE continued:-

Obtaining E-NFA for given RE:-

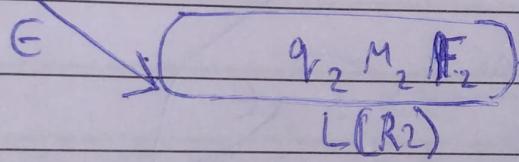
Case 1: $R = R_1 + R_2$

$$\text{Then } L = L(R_1) + L(R_2) = L(R_1 + R_2)$$

Apparatus :

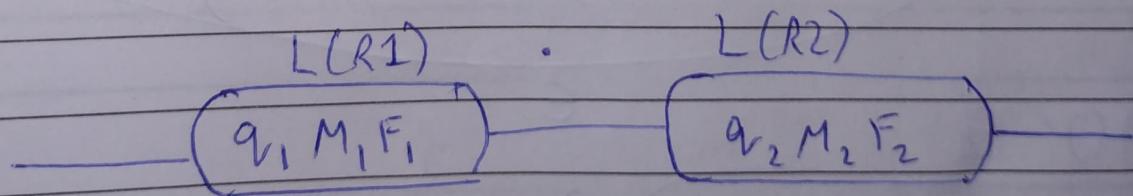


Formula with S. I. unit :



Case 2: $R = R_1 \cdot R_2$

Principle : Then $L = L(R_1) \cdot L(R_2) = L(R_1 \cdot R_2)$



Case 3: $R = R_1^*$

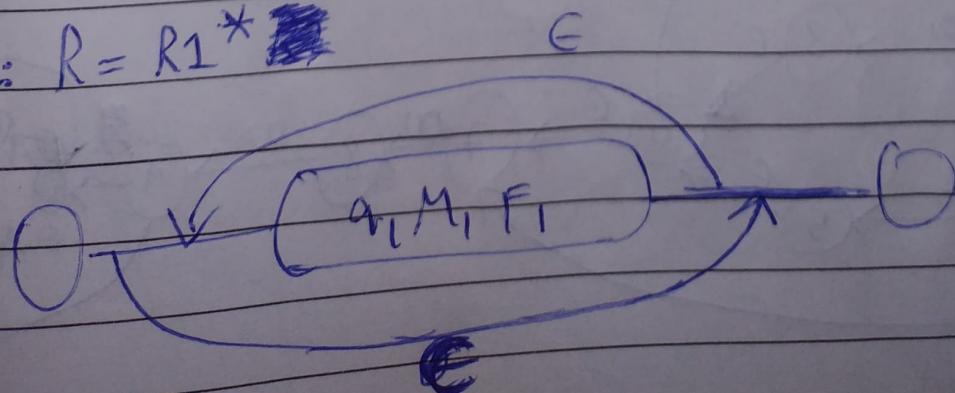
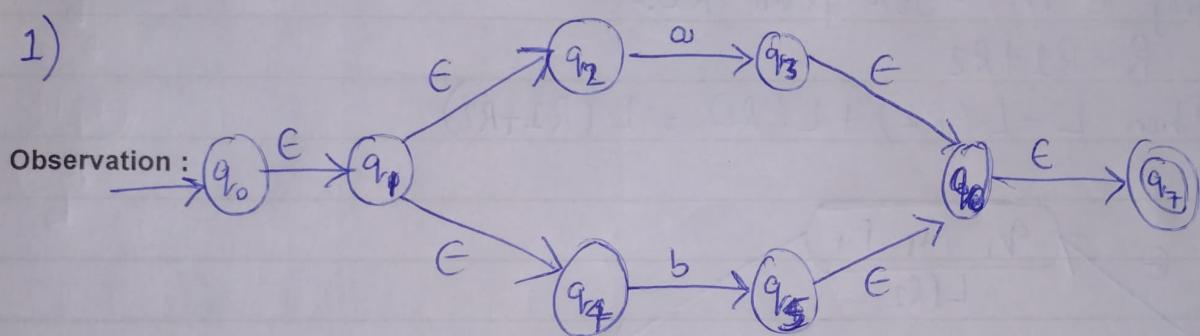


Diagram :

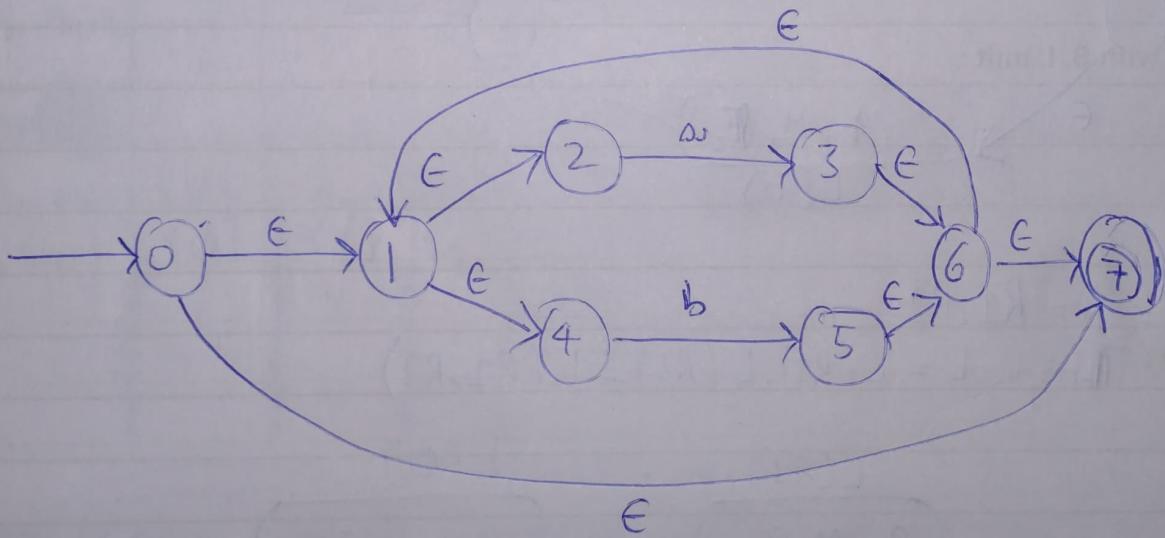
Write ϵ -NFA for following RE's:-

- 1) $a+b$
- 2) $(a+b)^*$
- 3) $(a+b)^*$ or $(a+b)^*$
- 4) $a^*b^* + c^*$

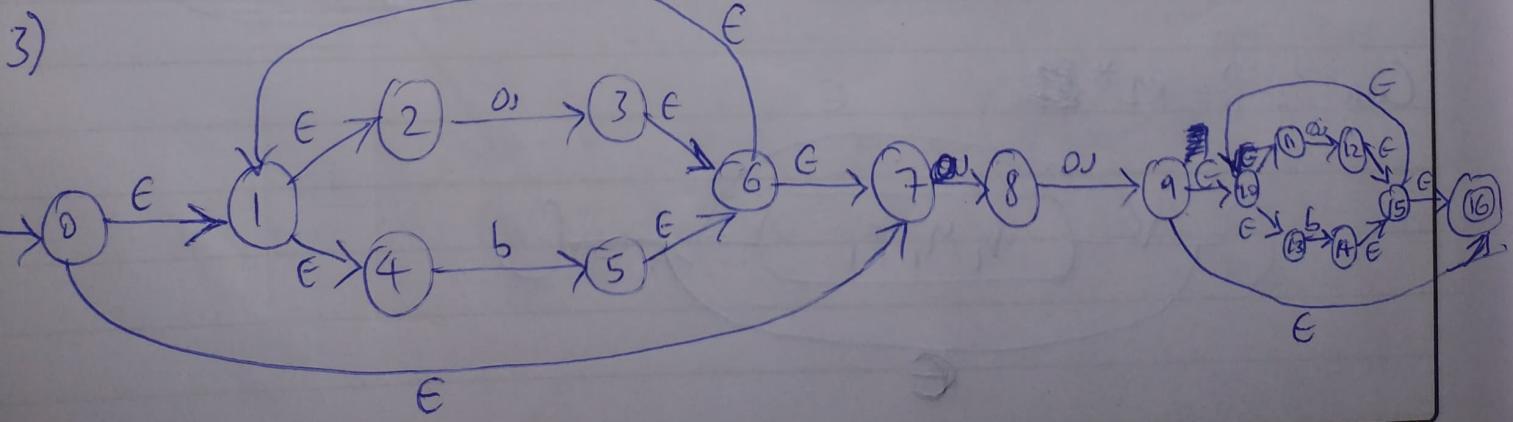
1)



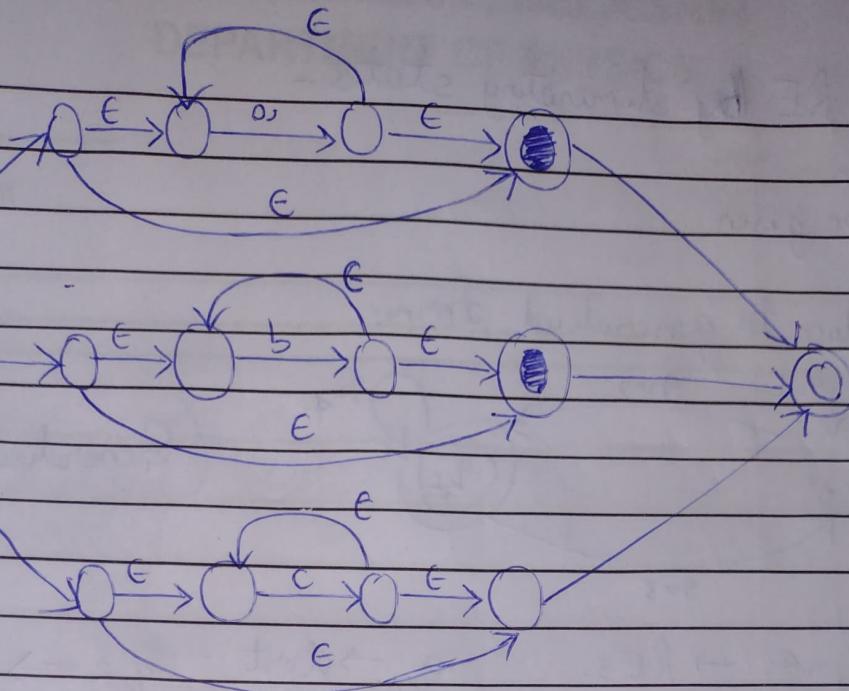
2)



3)

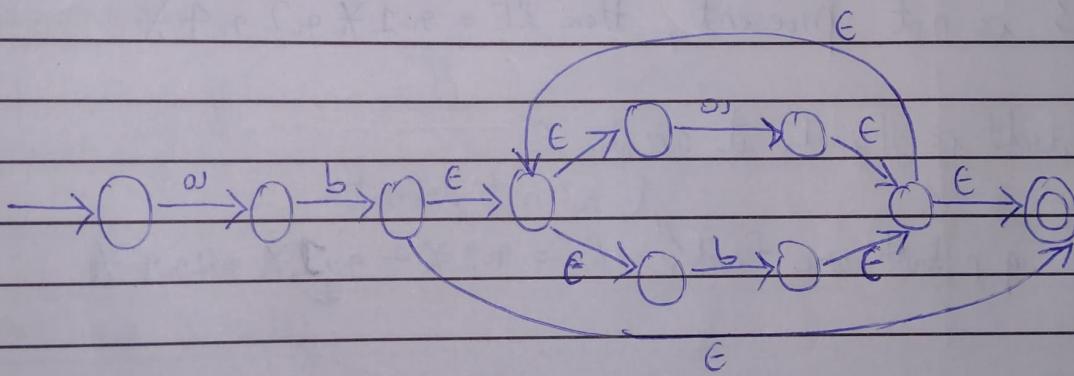


4)

5) $ab(a+b)^*$ 6) $(a+b)^*00$

7) 0011

5)

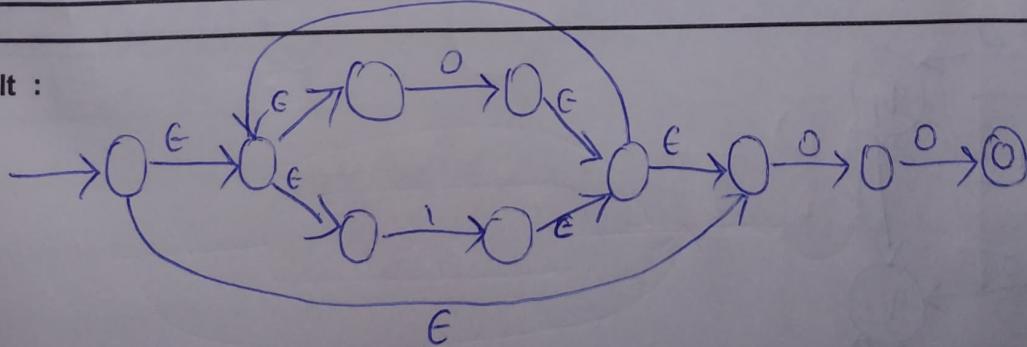


6)

ε

7) $\epsilon \rightarrow 0 \xrightarrow{a} 0 \xrightarrow{a} 0 \xrightarrow{a} 0 \xrightarrow{a} 0$

Result :

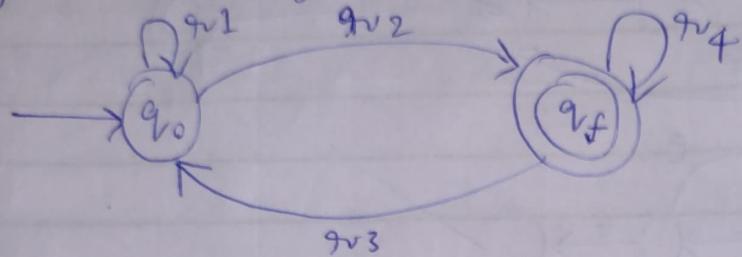


Calculation :

Obtaining RE by eliminating states:-

DFA will be given.

Try to reduce to generalised form:



(Generalised reduced graph)

$r_1, r_2, r_3, r_4 \rightarrow \text{RE}'s.$ $q_0 \rightarrow \text{start}$ $q_f \rightarrow \text{final}$

$$RE = r_1 * r_2 (r_4 + r_3 | r_1 * r_2) *$$

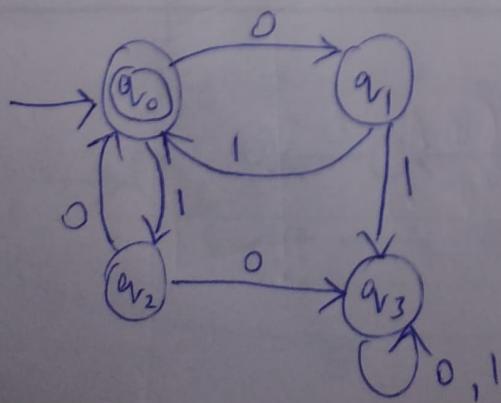
If r_3 is not present, then $RE = r_1 * r_2 r_4 *$

If q_0 itself is final, it accepts ϵ .

If q_0 & q_f both are final, $\& r_3 \text{ not present}$ $RE = r_1 * + r_1 \cancel{*} r_2 r_4 *$

Ex:-

1) Obtain RE for given trans. diagram:-

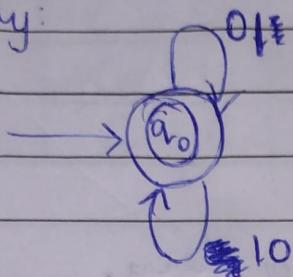


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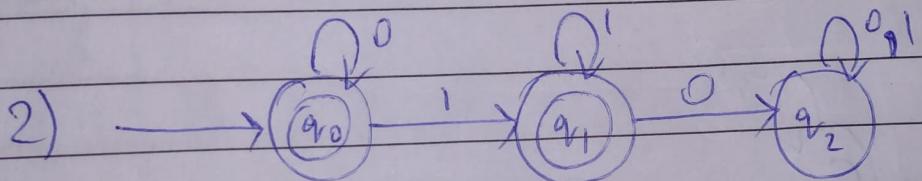
Aim : Finally:



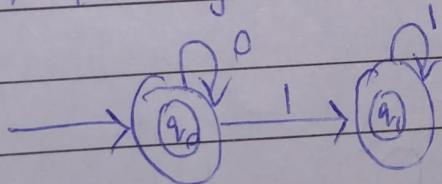
Apparatus :

$$RE = (01 + 10)^*$$

Formula with S. I. unit :



Principle : → Finally:



$$RE = 0^* 11.^* + 0^* \cancel{0000000}$$

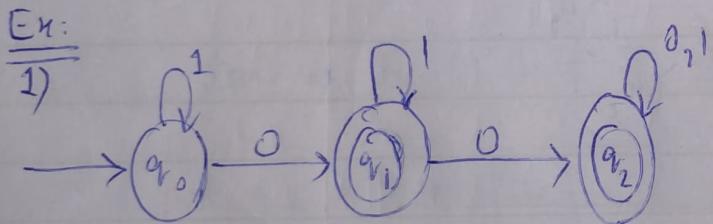
Diagram :

Table filling algorithm :-

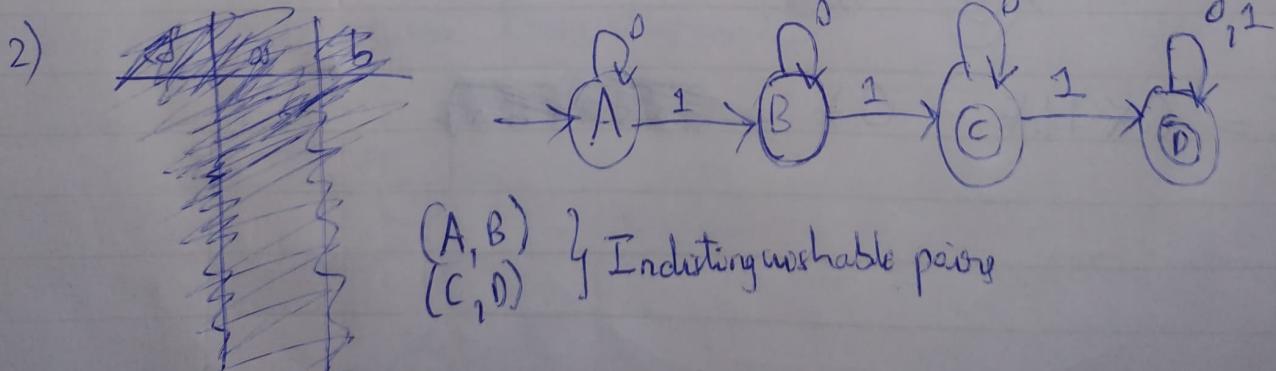
- 1) Indistinguishable states (pairs)
- 2) Distinguishable states
- 3) Transition table / diagram
- 4) Minimised DFA.

1) Indistinguishable / Equivalent states :-

Observation : If $p \& q$ are 2 states & w is a string,
 $(\delta(p, w) \in F \& \delta(q, w) \in F)$ or $(\delta(p, w) \notin F \text{ or } \delta(q, w) \notin F)$
Then $p \& q$ are final states. or $p \& q$, both are non-final.
Hence $p \& q$ are equivalent.



(q_1, q_2) Indistinguishable pair.



δ	0	1
$\rightarrow A$	B	F
B	G	C
*	C	A
D	C	G
E	H	F
F	C	G
G	G	E
H	G	C

TFA :-

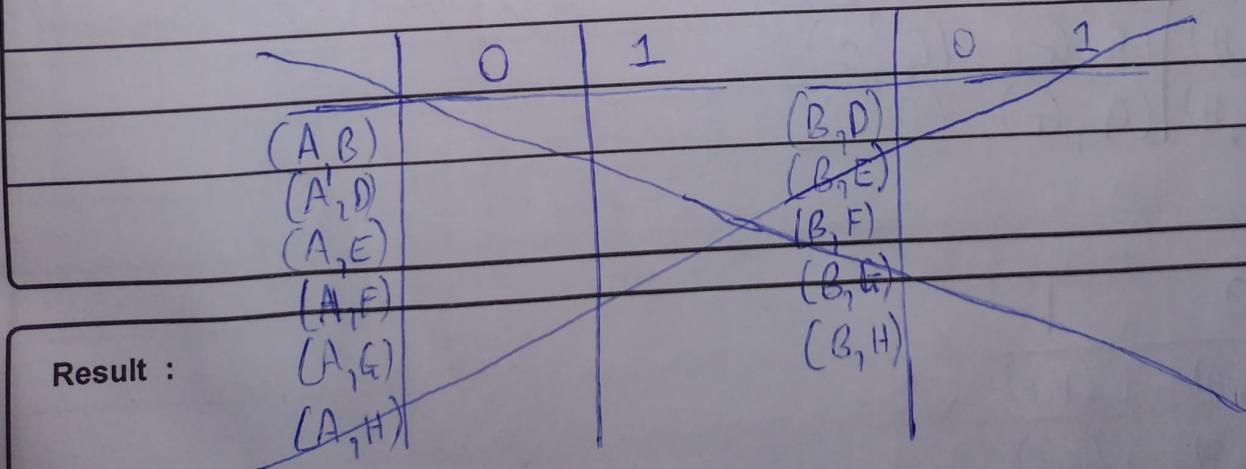
B	X					
C	X	X				
D	X	X	X			
E		X	X	X		
F	X	X	X	X		
G	X	X	X	X	X	X
H	X	X	X	X	X	X
A	B	C	D	E	F	G

Vertically start with 2nd state
Horizontally start with 1st state

$X \rightarrow DP^s$.

First mark X in row & column of final state.

$(A, C) (B, C) (D, C) (E, C) (F, C) (G, C) (H, C) \rightarrow DP^s$



Calculation :

S1)

	O	I
(A, B)	(B, G)	(F, C)
(A, D)	(B, C)	(F, G)
(A, E)	(B, H)	(F, F)
(A, F)	(B, C)	(F, G)
(A, G)	(B, G)	(F, E)
(A, H)	(B, G)	(F, C)
(B, D)	(G, C)	(E, G)
(B, E)	(G, H)	(C, F)
(B, F)	(G, C)	(C, G)
(B, G)	(G, G)	(C, E)
(B, H)	(G, G)	(C, C)
(D, E)	(C, H)	(G, F)
(D, F)	(C, C)	(G, G)
(D, G)	(C, G)	(G, E)
(D, H)	(C, G)	(G, C)
(E, F)	(H, C)	(F, G)
(E, G)	(H, G)	(F, E)
(E, H)	(H, G)	(F, C)
(F, G)	(C, G)	(G, E)
(F, H)	(C, G)	(G, C)
(G, H)	(G, G)	(E, C)

S3)

	O	I
(A, E)	(B, H)	(F, F)
(B, H)	(G, G)	(C, C)
(D, F)	(C, C)	(G, G)

S2)

	O	I
(A, E)	(B, H)	(F, F)
(A, G)	(B, G)	(F, E)
(B, H)	(G, G)	(C, C)
(D, F)	(C, C)	(G, G)
(E, H)	(H, G)	(F, E)

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Aim :

(A, E) , (B, H) , (D, F) are indistinguishable pairs.
 C & G are distinguishable.

	O	I	
Apparatus :	$\rightarrow (AE)$	(BH)	(DF) → don't write FF since both D & F are equivalent, write FF.
	$G \& C \leftarrow (BH)$	G	C
	Cuz available (DF)	C	G
on left side	* C	(AE)	C

Formula with S. I. unit : G | G | (AE) If we get only A or E or like that, write complete Indistinguishable pair (AE) .

Principle :

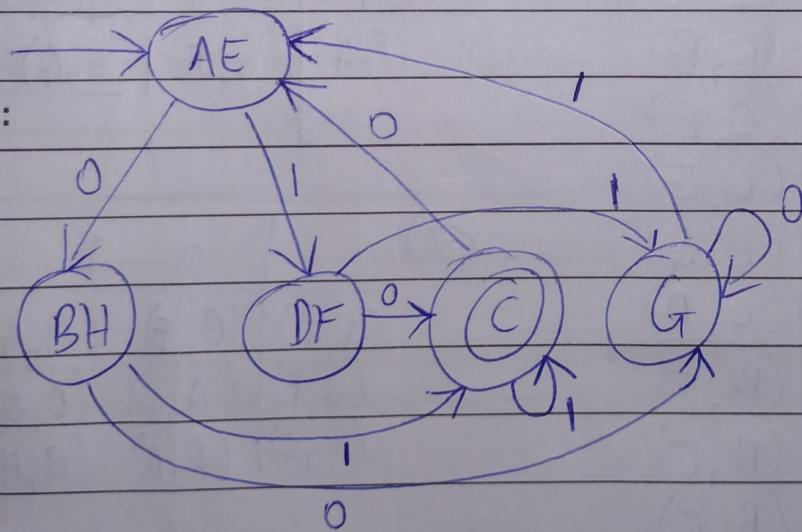


Diagram :

	O	I
A	B	A
B	A	C
C	D	B
X	D	A
E	D	F
F	G	E
G	F	G
H	G	D

B	X					
C	X	X				
D	X	X	X			
E	X	X		X		
F	X		X	X	X	
G		X	X	X	X	X
H	X	X	X	X	X	X
	A	B	C	D	E	F
						G

Observation :

S1)

	O	I
(A, B)	(B, A)	(A, C)
✓ (A, C)	(B, D)	(A, B)
✓ (A, E)	(B, D)	(A, F)
(A, F)	(B, G)	(A, E)
(A, G)	(B, F)	(A, G)
✓ (A, H)	(B, G)	(A, D)
✓ (B, C)	(A, D)	(C, B)
(B, E)	(A, D)	(C, F)
(B, F)	(A, G)	(C, E)
(B, G)	(A, F)	(C, G)
✓ (B, H)	(A, G)	(C, D)
(C, E)	(D, D)	(B, F)
✓ (C, F)	(D, G)	(B, E)
✓ (C, G)	(D, F)	(B, G)
✓ (C, H)	(D, G)	(B, D)
✓ (E, F)	(D, G)	(F, E)
✓ (E, G)	(D, F)	(F, G)
✓ (E, H)	(D, G)	(F, D)
(F, G)	(G, E)	(E, G)
✓ (F, H)	(G, G)	(E, D)
✓ (G, H)	(F, G)	(G, D)

S2)

	O	I
✓ (A, B)	(B, A)	(A, C)
✓ (A, F)	(B, G)	(A, E)
(A, G)	(B, F)	(A, G)
(B, F)	(A, G)	(C, E)
✓ (B, G)	(A, F)	(C, G)
(C, E)	(D, D)	(B, F)
✓ (F, G)	(G, F)	(E, G)

S3)

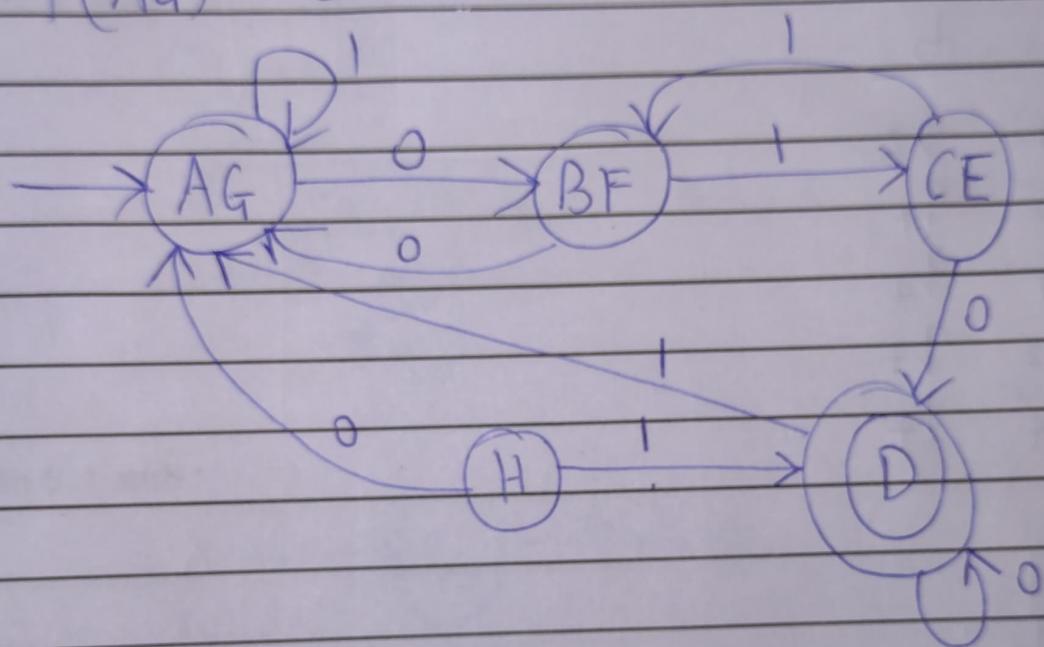
	O	I
(A, G)	(B, A)	(A, G)
(B, F)	(A, G)	(C, E)
(C, E)	(D, D)	(B, F)

$\therefore (A, G) (B, F) (C, E)$ — IDP

$D, H \rightarrow$ Distinguishable

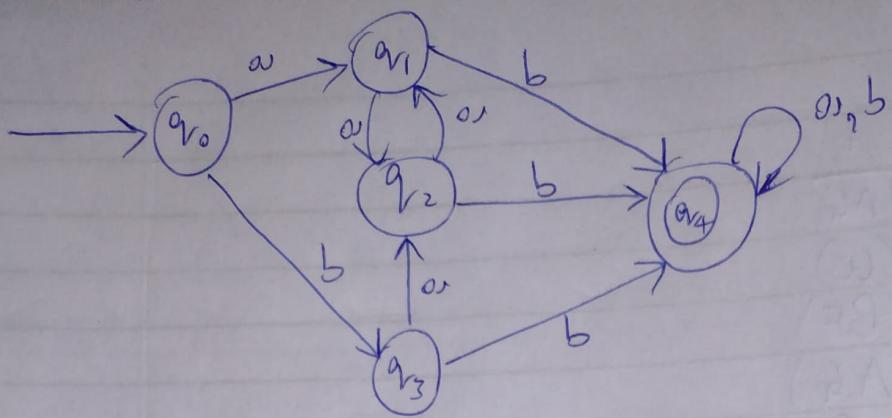
T T (Final) :-

	0	1	
→	(A, E)	(B, F)	(A, G)
	(B, F)	(A, G)	(C, E)
	(C, E)	D	(B, F)
*	D	D	(A, G)
H	(A, G)	D	



Result :

Calculation : Obtain minimised DFA.



TT:-

	a	b
$\rightarrow q_0$	q_1	q_3
q_1	q_2	q_4
q_2	q_1	q_4
q_3	q_2	q_4
q_4	q_4	q_4

q_1	X			
q_2	X			
q_3	X			
q_4	X	X	X	
	q_0	q_1	q_2	q_3

S1)

	a	b
(q_0, q_1)	(q_1, q_2)	(q_3, q_4)
(q_0, q_2)	(q_1, q_1)	(q_3, q_4)
(q_0, q_3)	(q_1, q_2)	(q_3, q_4)
(q_1, q_2)	(q_2, q_1)	(q_4, q_4)
(q_1, q_3)	(q_2, q_2)	(q_4, q_4)
(q_2, q_3)	(q_1, q_2)	(q_4, q_4)

S2)

	a	b
(q_1, q_2)	(q_2, q_1)	(q_4, q_4)
(q_1, q_3)	(q_2, q_2)	(q_4, q_4)
(q_2, q_3)	(q_1, q_2)	(q_4, q_4)

$\therefore (q_1, q_2) \{ q_1, q_3 \}$
 $\{ q_2, q_3 \} \rightarrow \text{IDP's.}$

Take (q_1, q_2, q_3) 1 state
 Transition property

Title of Experiment _____

Aim: q_0 & q_4 are distinguishable

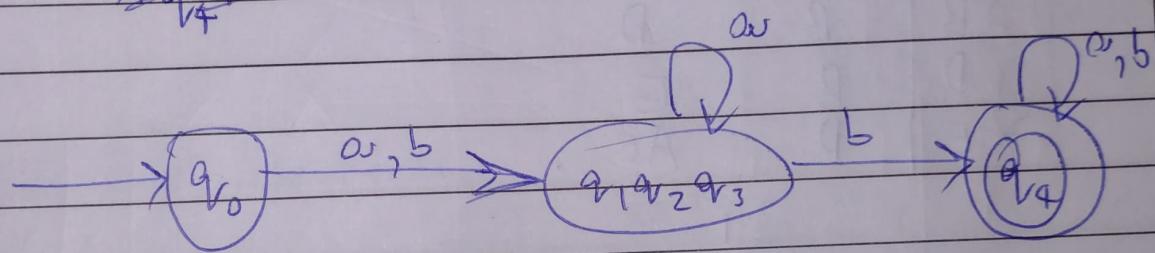
Fined TT:-

T:-	q_0	b
$(q_1 q_2 q_3)$	$(q_2 q_1)$	q_4
$(q_1 q_3)$	$(q_1 q_2)$	q_4
$(q_1 q_2)$	$(q_2 q_1)$	q_4
$(q_1 q_3)$	$(q_2 q_1)$	q_4
$\xrightarrow{q_0}$	$* q_0$	
$\xrightarrow{q_4}$		

	0_1	b
$q_1 q_2 q_3$	$q_1 q_2 q_3$	q_4
$\rightarrow q_0$	$q_1 q_2 q_3$	$q_1 q_2 q_3$
$* q_4$	q_4	q_4

Apparatus :

Formula with S. I. unit :



TFA also called Myhill Nerode. (MN)

Principle :

S	D	I
A	B	C
B	B	D
C	B	C
D	B	E
E	D	C

B	X				
C		X			
D	X	X	X		
E	X	X	X	X	
	A	B	C	D	

Diagram :

S1)

	0	1
(A, B)	(B, B)	(C, D)
(A, C)	(B, B)	(C, C)
<u>(A, D)</u>	<u>(B, B)</u>	<u>(C, E)</u>
(B, C)	(B, B)	(D, C)
<u>(B, D)</u>	<u>(B, B)</u>	<u>(D, E)</u>
<u>(C, D)</u>	<u>(B, B)</u>	<u>(C, E)</u>

S2)

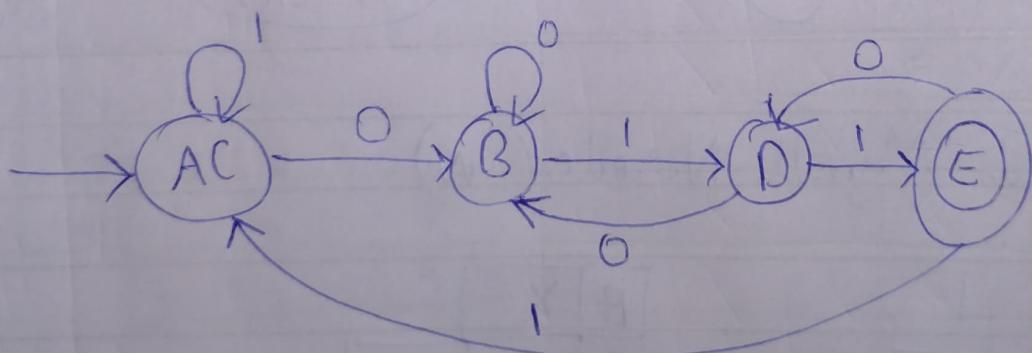
	0	1
(A, B)	(B, B)	<u>(C, D)</u>
(A, C)	(B, B)	(C, C)
<u>(B, C)</u>	<u>(B, B)</u>	<u>(D, C)</u>

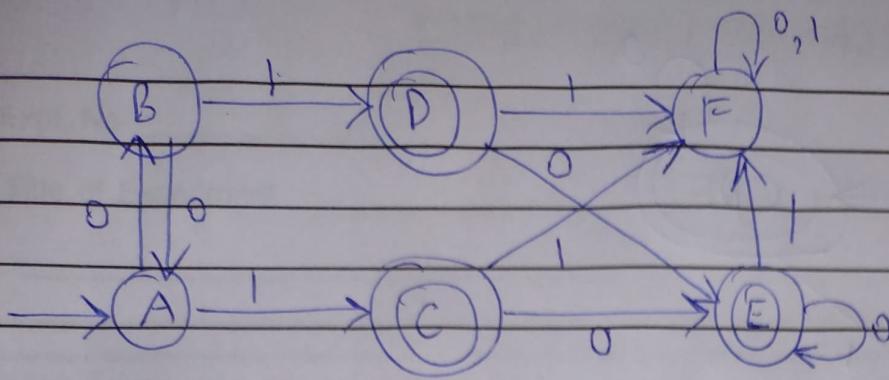
S3)

	0	1
(A, C)	(B, B)	(C, C)

Observation : (A, C) is IDP. BDE are distinguishable.

8	0	1
$\rightarrow AC$	B	AC
B	B	D
D	B	E
$\times E$	B	AC





If we get (C, 0) or (D, E) or both final states in pair, don't mark.

	0	1
→ A	B C	
B	A D	
* C	E F	
* D	E F	
* E	E F	
F	F F	

initially

B			
C	X	X	
D	X	X	
E	X	X	
F	X	X	X
A	B	C	D
			E

CD, DC not marked, as both are final

Don't remove trap state like F here.

S1)

	0	1
(A, B)	(B, A) C, D	
✓ (A, C)	(B, E) C, F	
✓ (A, D)	(B, E) C, F	
✓ (A, E)	(B, E) C, F	
✓ (A, F)	(B, F) C, F	
✓ (B, C)	A, E A, E	D, F
✓ (B, D)	A, E A, E	D, F

S2)

	0	1
(A, B)	(B, A) C, D	
(C, D)	(E, E) F, F	
(C, E)	(E, E) F, F	
(D, E)	(E, E) F, F	

AB, CD, CE, DE one IDP's
AB, CDE one IDP's

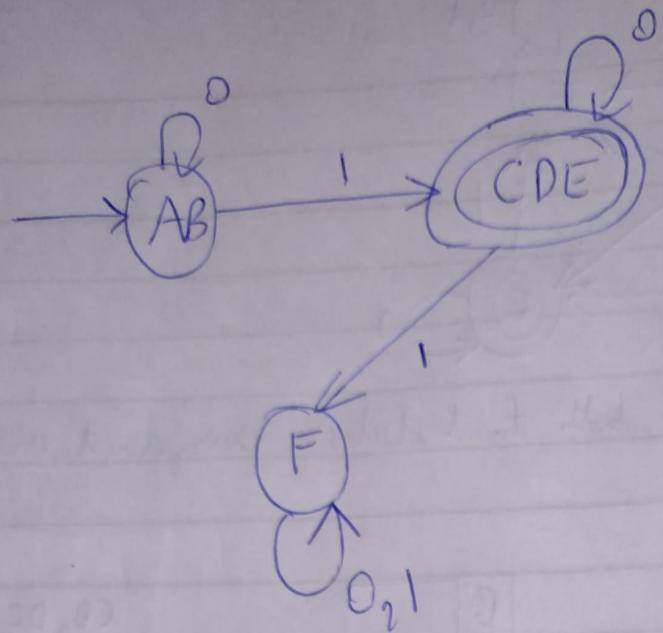
Result :

(B, E)	(A, E) A, F	D, F D, F
✓ (B, F)	(A, F)	D, F
(C, A)	(E, E)	F, F
(C, E)	(E, E)	F, F
✓ (D, E)	(E, E)	F, F
✓ (E, E)	(F, F)	

F is DP.

	0	1
→ AB	AB	CDE
✓ CDE	CDE	F
F	F	F

Calculation :



	O	I
→ A	B	E
B	C	F
* C	D	H
D	E	H
E	F	I
* F	G	B
G	H	B
H	I	C
* I	A	E

B	X					
C	X	X				
D		X	X			
E	X		X	X		
F	X	X		X	X	
G		X	X		X	X
H	X		X	X		X
I	X	X		X	X	X
	A	B	C	D	E	F
					G	H

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Aim :	S1)	S	O	I	S	O	I
	✓ (A, B)	(A, C)	(E, F)		(A, D)	(B, E)	(E, H)
	(A, D)	(B, E)	(E, H)		(A, G)	(B, H)	(E, B)
	✓ (A, E)	(B, F)	(E, I)		(B, E)	(C, F)	(F, I)
Apparatus :	(A, G)	(B, H)	(E, B)		(B, H)	(C, I)	(F, C)
	✓ (A, H)	(B, I)	(E, C)		(C, F)	(D, G)	(H, B)
	✓ (B, D)	(C, E)	(F, H)		(C, I)	(D, A)	(H, E)
	(B, E)	(C, F)	(F, I)		(D, G)	(E, H)	(H, B)
Formula with S. I. unit:	(B, G)	(C, H)	(F, B)		(E, H)	(F, I)	(I, C)
	(B, H)	(C, I)	(F, C)		(F, I)	(G, A)	(B, E)
	(C, F)	(D, G)	(H, B)		(A, D), (A, G), (B, E), (B, H)		
	(C, I)	(D, A)	(H, E)		(C, F), (C, I), (D, G), (E, H), (F, I) → IDP's		
	✓ (D, E)	(E, F)	(H, I)				
Principle :	(D, G)	(E, H)	(H, B)				
	(D, H)	(E, I)	(H, C)		(A, D)(A, G)(D, G) → ADG		
	✓ (E, G)	(F, H)	(I, B)		(B, E)(B, H)(E, H) → BEH		
	(E, H)	(F, I)	(I, C)		(C, F)(C, I)(F, I) → CFI		
	(F, I)	(G, A)	(B, E)				
	✓ (G, H)	(H, I)	(B, C)		No DP's.		

	S	O	I
→ ADG	BEH	BEH	
BEH	CFI	CFI	
*CFI	ADG	BEH	

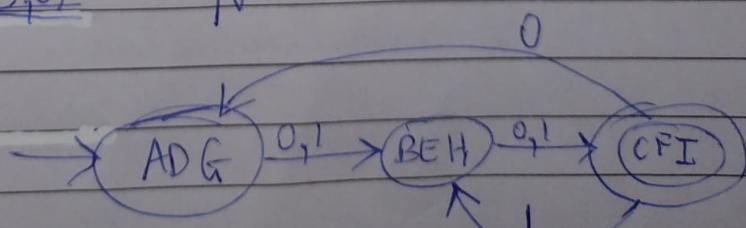
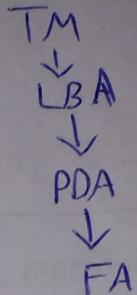
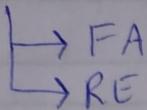


Diagram :

Pumping Lemma



$L \rightarrow \text{Finite}$



If we can draw DFA^{or write RE} for L , it is regular language, otherwise its irregular.

* Negativity test.

Observation :

Pumping Lemma statement: Suppose L is a regular language having pumping length p such that s is a string in the language such that
 $|s| > p$ where string s can be divided into 3 parts x, y, z
 $\xrightarrow{x y z = s}$

such that following 3 conditions are true:

- i) $ny^i z, i \geq 0 \in L$
- ii) $|y| > 0$
- iii) $|xy| \leq p$

Using PL, show that $L = \{a^n b^n \mid n \geq 0\}$ is not regular language.

$$S = a^p b^p, p=7 \quad (\text{Can take any length}).$$

$\begin{matrix} \checkmark \\ \downarrow \\ x \ y \ z \end{matrix}$

$$S = \underbrace{a a a a a a a}_{x} \underbrace{b b b b b b b}_{z}, \underbrace{a a a a a}_{y}$$

x, y appears in 'a' part

$$x = aaaa, y = aaaa, z = aaaaaaaaa$$

$$\text{Let } i=0$$

$$\therefore xy^iz = aaaaaaaa \notin L$$

$\therefore L$ is non regular.

check whether

Using PL ~~show that~~ $L = \{a^i b^j \mid i \leq j\}$ is regular or not.

$$S = a^p b^{p+1}, p=4$$

$$S = aaaaaabbbbb$$

$$\underbrace{aaaaaa}_{x} \underbrace{bbbbbb}_{y} b$$

$$xy^iz \text{ for } i=3 \text{ is } aaaaaaaa bbbbbbb \notin L$$

$\therefore L$ is not regular.

Using PL, show that $L = \{a^j b^j \mid j \geq 1\}$ is non regular.

Result :