

# Subject Name Solutions

4331101 – Summer 2024

Semester 1 Study Material

*Detailed Solutions and Explanations*

## Question 1(a) [3 marks]

Define node, branch and loop with suitable diagram.

### Solution

Diagram:

#### Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A((Node A)) --{Branch 1\}--> B((Node B))
    A --{Branch 2\}--> C((Node C))
    A --{Branch 3\}--> D((Node D))
    B --{Branch 4\}--> E((Node E))
    C --{Branch 5\}--> F((Node F))
    D --{Branch 6\}--> G((Node G))
    E --{Branch 7\}--> H((Node H))
    F --{Branch 8\}--> I((Node I))
    G --{Branch 9\}--> J((Node J))
    H --{Branch 10\}--> K((Node K))
    I --{Branch 11\}--> L((Node L))
    J --{Branch 12\}--> M((Node M))
    K --{Branch 13\}--> N((Node N))
    L --{Branch 14\}--> O((Node O))
    M --{Branch 15\}--> P((Node P))
    N --{Branch 16\}--> Q((Node Q))
    O --{Branch 17\}--> R((Node R))
    P --{Branch 18\}--> S((Node S))
    Q --{Branch 19\}--> T((Node T))
    R --{Branch 20\}--> U((Node U))
    S --{Branch 21\}--> V((Node V))
    T --{Branch 22\}--> W((Node W))
    U --{Branch 23\}--> X((Node X))
    V --{Branch 24\}--> Y((Node Y))
    W --{Branch 25\}--> Z((Node Z))
    X --{Branch 26\}--> AA((Node A))
    Y --{Branch 27\}--> AB((Node B))
    Z --{Branch 28\}--> AC((Node C))
    AA --{Branch 29\}--> AD((Node D))
    AB --{Branch 30\}--> AE((Node E))
    AC --{Branch 31\}--> AF((Node F))
    AD --{Branch 32\}--> AG((Node G))
    AE --{Branch 33\}--> AH((Node H))
    AF --{Branch 34\}--> AI((Node I))
    AG --{Branch 35\}--> AJ((Node J))
    AH --{Branch 36\}--> AK((Node K))
    AI --{Branch 37\}--> AL((Node L))
    AJ --{Branch 38\}--> AM((Node M))
    AK --{Branch 39\}--> AN((Node N))
    AL --{Branch 40\}--> AO((Node O))
    AM --{Branch 41\}--> AP((Node P))
    AN --{Branch 42\}--> AQ((Node Q))
    AO --{Branch 43\}--> AR((Node R))
    AP --{Branch 44\}--> AS((Node S))
    AQ --{Branch 45\}--> AT((Node T))
    AR --{Branch 46\}--> AU((Node U))
    AS --{Branch 47\}--> AV((Node V))
    AT --{Branch 48\}--> AW((Node W))
    AU --{Branch 49\}--> AX((Node X))
    AV --{Branch 50\}--> AY((Node Y))
    AW --{Branch 51\}--> AZ((Node Z))
    AX --{Branch 52\}--> BA((Node A))
    AY --{Branch 53\}--> BB((Node B))
    AZ --{Branch 54\}--> BC((Node C))
    BA --{Branch 55\}--> BD((Node D))
    BB --{Branch 56\}--> BE((Node E))
    BC --{Branch 57\}--> BF((Node F))
    BD --{Branch 58\}--> BG((Node G))
    BE --{Branch 59\}--> BH((Node H))
    BF --{Branch 60\}--> BI((Node I))
    BG --{Branch 61\}--> BJ((Node J))
    BH --{Branch 62\}--> BK((Node K))
    BI --{Branch 63\}--> BL((Node L))
    BJ --{Branch 64\}--> BM((Node M))
    BK --{Branch 65\}--> BN((Node N))
    BL --{Branch 66\}--> BO((Node O))
    BM --{Branch 67\}--> BP((Node P))
    BN --{Branch 68\}--> BQ((Node Q))
    BO --{Branch 69\}--> BR((Node R))
    BP --{Branch 70\}--> BS((Node S))
    BQ --{Branch 71\}--> BT((Node T))
    BR --{Branch 72\}--> BU((Node U))
    BS --{Branch 73\}--> BV((Node V))
    BT --{Branch 74\}--> BW((Node W))
    BU --{Branch 75\}--> BX((Node X))
    BV --{Branch 76\}--> BY((Node Y))
    BW --{Branch 77\}--> BZ((Node Z))
    BX --{Branch 78\}--> CA((Node A))
    BY --{Branch 79\}--> CB((Node B))
    BZ --{Branch 80\}--> CC((Node C))
    CA --{Branch 81\}--> CD((Node D))
    CB --{Branch 82\}--> CE((Node E))
    CC --{Branch 83\}--> CF((Node F))
    CD --{Branch 84\}--> CG((Node G))
    CE --{Branch 85\}--> CH((Node H))
    CF --{Branch 86\}--> CI((Node I))
    CG --{Branch 87\}--> CJ((Node J))
    CH --{Branch 88\}--> CK((Node K))
    CI --{Branch 89\}--> CL((Node L))
    CJ --{Branch 90\}--> CM((Node M))
    CK --{Branch 91\}--> CN((Node N))
    CL --{Branch 92\}--> CO((Node O))
    CM --{Branch 93\}--> CP((Node P))
    CN --{Branch 94\}--> CQ((Node Q))
    CO --{Branch 95\}--> CR((Node R))
    CP --{Branch 96\}--> CS((Node S))
    CQ --{Branch 97\}--> CT((Node T))
    CR --{Branch 98\}--> CU((Node U))
    CS --{Branch 99\}--> CV((Node V))
    CT --{Branch 100\}--> CW((Node W))
    CU --{Branch 101\}--> CX((Node X))
    CV --{Branch 102\}--> CY((Node Y))
    CW --{Branch 103\}--> CZ((Node Z))
    CX --{Branch 104\}--> DA((Node A))
    CY --{Branch 105\}--> DB((Node B))
    CZ --{Branch 106\}--> DC((Node C))
    DA --{Branch 107\}--> DD((Node D))
    DB --{Branch 108\}--> DE((Node E))
    DC --{Branch 109\}--> DF((Node F))
    DD --{Branch 110\}--> DG((Node G))
    DE --{Branch 111\}--> DH((Node H))
    DF --{Branch 112\}--> DI((Node I))
    DG --{Branch 113\}--> DJ((Node J))
    DH --{Branch 114\}--> DK((Node K))
    DI --{Branch 115\}--> DL((Node L))
    DJ --{Branch 116\}--> DM((Node M))
    DK --{Branch 117\}--> DN((Node N))
    DL --{Branch 118\}--> DO((Node O))
    DM --{Branch 119\}--> DP((Node P))
    DN --{Branch 120\}--> DQ((Node Q))
    DO --{Branch 121\}--> DR((Node R))
    DP --{Branch 122\}--> DS((Node S))
    DQ --{Branch 123\}--> DT((Node T))
    DR --{Branch 124\}--> DU((Node U))
    DS --{Branch 125\}--> DV((Node V))
    DT --{Branch 126\}--> DW((Node W))
    DU --{Branch 127\}--> DX((Node X))
    DV --{Branch 128\}--> DY((Node Y))
    DW --{Branch 129\}--> DZ((Node Z))
    DX --{Branch 130\}--> EA((Node A))
    DY --{Branch 131\}--> EB((Node B))
    DZ --{Branch 132\}--> EC((Node C))
    EA --{Branch 133\}--> ED((Node D))
    EB --{Branch 134\}--> EE((Node E))
    EC --{Branch 135\}--> EF((Node F))
    ED --{Branch 136\}--> EG((Node G))
    EE --{Branch 137\}--> EH((Node H))
    EF --{Branch 138\}--> EI((Node I))
    EG --{Branch 139\}--> EJ((Node J))
    EH --{Branch 140\}--> EK((Node K))
    EI --{Branch 141\}--> EL((Node L))
    EJ --{Branch 142\}--> EM((Node M))
    EK --{Branch 143\}--> EN((Node N))
    EL --{Branch 144\}--> EO((Node O))
    EM --{Branch 145\}--> EP((Node P))
    EN --{Branch 146\}--> EQ((Node Q))
    EO --{Branch 147\}--> ER((Node R))
    EP --{Branch 148\}--> ES((Node S))
    EQ --{Branch 149\}--> ET((Node T))
    ER --{Branch 150\}--> EU((Node U))
    ES --{Branch 151\}--> EV((Node V))
    ET --{Branch 152\}--> EW((Node W))
    EU --{Branch 153\}--> EX((Node X))
    EV --{Branch 154\}--> EY((Node Y))
    EW --{Branch 155\}--> EZ((Node Z))
    EX --{Branch 156\}--> FA((Node A))
    EY --{Branch 157\}--> FB((Node B))
    EZ --{Branch 158\}--> FC((Node C))
    FA --{Branch 159\}--> FD((Node D))
    FB --{Branch 160\}--> FE((Node E))
    FC --{Branch 161\}--> FF((Node F))
    FD --{Branch 162\}--> FG((Node G))
    FE --{Branch 163\}--> FH((Node H))
    FF --{Branch 164\}--> FI((Node I))
    FG --{Branch 165\}--> FJ((Node J))
    FH --{Branch 166\}--> FK((Node K))
    FI --{Branch 167\}--> FL((Node L))
    FJ --{Branch 168\}--> FM((Node M))
    FK --{Branch 169\}--> FN((Node N))
    FL --{Branch 170\}--> FO((Node O))
    FM --{Branch 171\}--> FP((Node P))
    FN --{Branch 172\}--> FQ((Node Q))
    FO --{Branch 173\}--> FR((Node R))
    FP --{Branch 174\}--> FS((Node S))
    FQ --{Branch 175\}--> FT((Node T))
    FR --{Branch 176\}--> FU((Node U))
    FS --{Branch 177\}--> FV((Node V))
    FT --{Branch 178\}--> FW((Node W))
    FU --{Branch 179\}--> FX((Node X))
    FV --{Branch 180\}--> FY((Node Y))
    FW --{Branch 181\}--> FZ((Node Z))
    FX --{Branch 182\}--> GA((Node A))
    FY --{Branch 183\}--> GB((Node B))
    FZ --{Branch 184\}--> GC((Node C))
    GA --{Branch 185\}--> GD((Node D))
    GB --{Branch 186\}--> GE((Node E))
    GC --{Branch 187\}--> GF((Node F))
    GD --{Branch 188\}--> GE((Node E))
    GB --{Branch 189\}--> GD((Node D))
    GC --{Branch 190\}--> GB((Node B))
    GA --{Branch 191\}--> GA((Node A))
    GB --{Branch 192\}--> GB((Node B))
    GC --{Branch 193\}--> GC((Node C))
    GD --{Branch 194\}--> GD((Node D))
    GE --{Branch 195\}--> GE((Node E))
    GF --{Branch 196\}--> GF((Node F))
    GH --{Branch 197\}--> GH((Node G))
    GI --{Branch 198\}--> GI((Node I))
    GJ --{Branch 199\}--> GJ((Node J))
    GK --{Branch 200\}--> GK((Node K))
    GL --{Branch 201\}--> GL((Node L))
    GM --{Branch 202\}--> GM((Node M))
    GN --{Branch 203\}--> GN((Node N))
    GO --{Branch 204\}--> GO((Node O))
    GP --{Branch 205\}--> GP((Node P))
    GQ --{Branch 206\}--> GQ((Node Q))
    GR --{Branch 207\}--> GR((Node R))
    GS --{Branch 208\}--> GS((Node S))
    GT --{Branch 209\}--> GT((Node T))
    GU --{Branch 210\}--> GU((Node U))
    GV --{Branch 211\}--> GV((Node V))
    GW --{Branch 212\}--> GW((Node W))
    GX --{Branch 213\}--> GX((Node X))
    GY --{Branch 214\}--> GY((Node Y))
    GZ --{Branch 215\}--> GZ((Node Z))
    HA((Node A))
    HB((Node B))
    HC((Node C))
    HD((Node D))
    HE((Node E))
    HF((Node F))
    HG((Node G))
    HH((Node H))
    HI((Node I))
    HJ((Node J))
    HK((Node K))
    HL((Node L))
    HM((Node M))
    HN((Node N))
    HO((Node O))
    HP((Node P))
    HQ((Node Q))
    HR((Node R))
    HS((Node S))
    HT((Node T))
    HU((Node U))
    HV((Node V))
    HW((Node W))
    HX((Node X))
    HY((Node Y))
    HZ((Node Z))
    IA((Node A))
    IB((Node B))
    IC((Node C))
    ID((Node D))
    IE((Node E))
    IF((Node F))
    IG((Node G))
    IH((Node H))
    II((Node I))
    IJ((Node J))
    IK((Node K))
    IL((Node L))
    IM((Node M))
    IN((Node N))
    IO((Node O))
    IP((Node P))
    IQ((Node Q))
    IR((Node R))
    IS((Node S))
    IT((Node T))
    IU((Node U))
    IV((Node V))
    IW((Node W))
    IX((Node X))
    IY((Node Y))
    IZ((Node Z))
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    JB((Node B))
    JC((Node C))
    JD((Node D))
    JE((Node E))
    JF((Node F))
    JG((Node G))
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    JI((Node I))
    JJ((Node J))
    JK((Node K))
    JL((Node L))
    JM((Node M))
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    JO((Node O))
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    JR((Node R))
    JS((Node S))
    JT((Node T))
    JU((Node U))
    JV((Node V))
    JW((Node W))
    JX((Node X))
    JY((Node Y))
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    KH((Node H))
    KI((Node I))
    KJ((Node J))
    KK((Node K))
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    KN((Node N))
    KO((Node O))
    KP((Node P))
    KQ((Node Q))
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    KS((Node S))
    KT((Node T))
    KU((Node U))
    KV((Node V))
    KW((Node W))
    KX((Node X))
    KY((Node Y))
    KZ((Node Z))
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    LB((Node B))
    LC((Node C))
    LD((Node D))
    LE((Node E))
    LF((Node F))
    LG((Node G))
    LH((Node H))
    LI((Node I))
    LJ((Node J))
    LK((Node K))
    LL((Node L))
    LM((Node M))
    LN((Node N))
    LO((Node O))
    LP((Node P))
    LQ((Node Q))
    LR((Node R))
    LS((Node S))
    LT((Node T))
    LU((Node U))
    LV((Node M))
    LW((Node W))
    LX((Node X))
    LY((Node Y))
    LZ((Node Z))
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    MB((Node B))
    MC((Node C))
    MD((Node D))
    ME((Node E))
    MF((Node F))
    MG((Node G))
    MH((Node H))
    MI((Node I))
    MJ((Node J))
    MK((Node K))
    ML((Node L))
    MM((Node M))
    MN((Node N))
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    MT((Node T))
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    MV((Node V))
    MW((Node W))
    MX((Node X))
    MY((Node Y))
    MZ((Node Z))
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    NC((Node C))
    ND((Node D))
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    NG((Node G))
    NH((Node H))
    NI((Node I))
    NJ((Node J))
    NK((Node K))
    NL((Node L))
    NM((Node M))
    NN((Node N))
    NO((Node O))
    NP((Node P))
    NQ((Node Q))
    NR((Node R))
    NS((Node S))
    NT((Node T))
    NU((Node U))
    NV((Node V))
    NW((Node W))
    NX((Node X))
    NY((Node Y))
    NZ((Node Z))
    OA((Node A))
    OB((Node B))
    OC((Node C))
    OD((Node D))
    OE((Node E))
    OF((Node F))
    OG((Node G))
    OH((Node H))
    OI((Node I))
    OJ((Node J))
    OK((Node K))
    OL((Node L))
    OM((Node M))
    ON((Node N))
    OO((Node O))
    OP((Node P))
    OQ((Node Q))
    OR((Node R))
    OS((Node S))
    OT((Node T))
    OU((Node U))
    OV((Node V))
    OW((Node W))
    OX((Node X))
    OY((Node Y))
    OZ((Node Z))
    PA((Node A))
    PB((Node B))
    PC((Node C))
    PD((Node D))
    PE((Node E))
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    PG((Node G))
    PH((Node H))
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    PJ((Node J))
    PK((Node K))
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    PO((Node O))
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    PQ((Node Q))
    PR((Node R))
    PS((Node S))
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    PX((Node X))
    PY((Node Y))
    PZ((Node Z))
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    QC((Node C))
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    QH((Node H))
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    QK((Node K))
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    QM((Node M))
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    QT((Node T))
    QU((Node U))
    QV((Node V))
    QW((Node W))
    QX((Node X))
    QY((Node Y))
    QZ((Node Z))
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    RB((Node B))
    RC((Node C))
    RD((Node D))
    RE((Node E))
    RF((Node F))
    RG((Node G))
    RH((Node H))
    RI((Node I))
    RJ((Node J))
    RK((Node K))
    RL((Node L))
    RM((Node M))
    RN((Node N))
    RO((Node O))
    RP((Node P))
    RQ((Node Q))
    RR((Node R))
    RS((Node S))
    RT((Node T))
    RU((Node U))
    RV((Node V))
    RW((Node W))
    RX((Node X))
    RY((Node Y))
    RZ((Node Z))
    SA((Node A))
    SB((Node B))
    SC((Node C))
    SD((Node D))
    SE((Node E))
    SF((Node F))
    SG((Node G))
    SH((Node H))
    SI((Node I))
    SJ((Node J))
    SK((Node K))
    SL((Node L))
    SM((Node M))
    SN((Node N))
    SO((Node O))
    SP((Node P))
    SQ((Node Q))
    SR((Node R))
    SS((Node S))
    ST((Node T))
    SU((Node U))
    SV((Node V))
    SW((Node W))
    SX((Node X))
    SY((Node Y))
    SZ((Node Z))
    TA((Node A))
    TB((Node B))
    TC((Node C))
    TD((Node D))
    TE((Node E))
    TF((Node F))
    TG((Node G))
    TH((Node H))
    TI((Node I))
    TJ((Node J))
    TK((Node K))
    TL((Node L))
    TM((Node M))
    TN((Node N))
    TO((Node O))
    TP((Node P))
    TQ((Node Q))
    TR((Node R))
    TS((Node S))
    TT((Node T))
    TU((Node U))
    TV((Node V))
    TW((Node W))
    TX((Node X))
    TY((Node Y))
    TZ((Node Z))
    UA((Node A))
    UB((Node B))
    UC((Node C))
    UD((Node D))
    UE((Node E))
    UF((Node F))
    UG((Node G))
    UH((Node H))
    UI((Node I))
    UJ((Node J))
    UK((Node K))
    UL((Node L))
    UM((Node M))
    UN((Node N))
    UO((Node O))
    UP((Node P))
    UQ((Node Q))
    UR((Node R))
    US((Node S))
    UT((Node T))
    UJ((Node J))
    UV((Node V))
    UW((Node W))
    UX((Node X))
    UY((Node Y))
    UZ((Node Z))
    VA((Node A))
    VB((Node B))
    VC((Node C))
    VD((Node D))
    VE((Node E))
    VF((Node F))
    VG((Node G))
    VH((Node H))
    VI((Node I))
    VJ((Node J))
    VK((Node K))
    VL((Node L))
    VM((Node M))
    VN((Node N))
    VO((Node O))
    VP((Node P))
    VQ((Node Q))
    VR((Node R))
    VS((Node S))
    VT((Node T))
    VU((Node U))
    VV((Node V))
    VW((Node W))
    VX((Node X))
    VY((Node Y))
    VZ((Node Z))
    WA((Node A))
    WB((Node B))
    WC((Node C))
    WD((Node D))
    WE((Node E))
    WF((Node F))
    WG((Node G))
    WH((Node H))
    WI((Node I))
    WJ((Node J))
    WK((Node K))
    WL((Node L))
    WM((Node M))
    WN((Node N))
    WO((Node O))
    WP((Node P))
    WQ((Node Q))
    WR((Node R))
    WS((Node S))
    WT((Node T))
    WU((Node U))
    WV((Node V))
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    WX((Node X))
    WY((Node Y))
    WZ((Node Z))
    XA((Node A))
    XB((Node B))
    XC((Node C))
    XD((Node D))
    XE((Node E))
    XF((Node F))
    XG((Node G))
    XH((Node H))
    XI((Node I))
    XJ((Node J))
    XK((Node K))
    XL((Node L))
    XM((Node M))
    XN((Node N))
    XO((Node O))
    XP((Node P))
    XQ((Node Q))
    XR((Node R))
    XS((Node S))
    XT((Node T))
    XU((Node U))
    XV((Node V))
    XW((Node W))
    XX((Node X))
    XY((Node Y))
    XZ((Node Z))
    YA((Node A))
    YB((Node B))
    YC((Node C))
    YD((Node D))
    YE((Node E))
    YF((Node F))
    YG((Node G))
    YH((Node H))
    YI((Node I))
    YJ((Node J))
    YK((Node K))
    YL((Node L))
    YM((Node M))
    YN((Node N))
    YO((Node O))
    YP((Node P))
    YQ((Node Q))
    YR((Node R))
    YS((Node S))
    YT((Node T))
    YU((Node U))
    YV((Node V))
    YW((Node W))
    YX((Node X))
    YY((Node Y))
    YZ((Node Z))
    ZA((Node A))
    ZB((Node B))
    ZC((Node C))
    ZD((Node D))
    ZE((Node E))
    ZF((Node F))
    ZG((Node G))
    ZH((Node H))
    ZI((Node I))
    ZJ((Node J))
    ZK((Node K))
    ZL((Node L))
    ZM((Node M))
    ZN((Node N))
    ZO((Node O))
    ZP((Node P))
    ZQ((Node Q))
    ZR((Node R))
    ZS((Node S))
    ZT((Node T))
    ZU((Node U))
    ZV((Node V))
    ZW((Node W))
    ZX((Node X))
    ZY((Node Y))
    ZZ((Node Z))
```

- **Node:** A point where two or more circuit elements join together
- **Branch:** A single element connecting two nodes
- **Loop:** Any closed path in a circuit where no node is encountered more than once

### Mnemonic

“NBA circuit” - Nodes are junctions, Branches are roads, Loops are Alternate paths

## Question 1(b) [4 marks]

Explain “Tree” and “Graph” of a network.

### Solution

Diagram:

#### Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    subgraph Network Graph
    direction LR
    A((A)) --{B((B))}--> B((B))
    A --{C((C))}--> C((C))
    end
```

```

B {-}{-}{-} D((D))}
C {-}{-}{-} D}
B {-}{-}{-} C}
end

subgraph Tree of Network
direction LR
E((A)) {-}{-}{-} F((B))}
E {-}{-}{-} G((C))}
F {-}{-}{-} H((D))}
end
{Highlighting}
{Shaded}

```

Feature	Graph	Tree
<b>Definition</b>	Complete topological representation of network	Connected subgraph containing all nodes but no loops
<b>Elements</b>	Contains all branches and nodes	Contains N-1 branches where N is number of nodes
<b>Loops</b>	Contains loops	No loops
<b>Application</b>	Used for complete circuit analysis	Used for simplifying network calculations

### Mnemonic

“GRAND Tree” - Graph has Routes And Nodes with Detours, Tree has only single Routes

## Question 1(c) [7 marks]

Explain “Mesh current Method” using suitable diagram.

### Solution

Diagram:

#### Mermaid Diagram (Code)

```

{Shaded}
{Highlighting}[]
graph LR
    subgraph Mesh 1
    A((+)) {-}{-} R1 {-}{-}{-} B((+))}
    B {-}{-} R3 {-}{-}{-} C((+))}
    C {-}{-} R5 {-}{-}{-} A}
    end

    subgraph Mesh 2
    B {-}{-} R2 {-}{-}{-} D((+))}
    D {-}{-} R4 {-}{-}{-} C}
    C {-}{-} R3 {-}{-}{-} B}
    end

    style Mesh 1 fill:#f9f,stroke:#333,stroke-width:2px}
    style Mesh 2 fill:#bbf,stroke:#333,stroke-width:2px}
{Highlighting}
{Shaded}

```

Step	Description
1	Identify independent meshes in the circuit

- 2 Assign mesh currents ( $I_1, I_2, etc.$ ) in clockwise direction
- 3 Apply KVL to each mesh
- 4 Form equations using:  $\sum R \cdot I(\text{own}) - \sum R \cdot I(\text{adjacent}) = \sum V$
- 5 Solve the simultaneous equations

- **Advantage:** Fewer equations than branch current method
- **Application:** Best for planar networks
- **Limitation:** Less efficient for non-planar networks

#### Mnemonic

“MIAMI” - Meshes Identified, Assign currents, Make equations, Intersection currents calculated, Solve

### Question 1(c OR) [7 marks]

Explain “Node pair voltage Method” using suitable diagram.

#### Solution

Diagram:

#### Mermaid Diagram (Code)

```
{Shaded}
{Highlighting} []
graph LR
    A((Node 1)) --- I1 --- B((Node 2))
    A --- I2 --- C((Node 3))
    B --- I3 --- C
    B --- I4 --- D((Reference))
    C --- I5 --- D
    A --- I6 --- D
{Highlighting}
{Shaded}
```

Step	Description
1	Select a reference node (ground)
2	Assign node voltages ( $V_1, V_2, etc.$ ) to remaining nodes
3	Apply KCL at each node (except reference)
4	Express currents in terms of node voltages using Ohm's Law
5	Solve the simultaneous equations

- **Advantage:** Fewer equations than mesh method for circuits with many meshes
- **Application:** Efficient for non-planar circuits
- **Key equation:**  $\sum G \cdot V(\text{own}) - \sum G \cdot V(\text{adjacent}) = \sum I$

#### Mnemonic

“GRAND” - Ground node fixed, Remaining nodes numbered, Apply KCL, Note voltage differences, Derive solutions

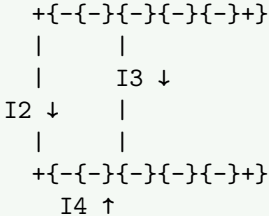
### Question 2(a) [3 marks]

Explain KCL with example.

#### Solution

Diagram:

I1



**Kirchhoff's Current Law (KCL):** The algebraic sum of all currents entering and leaving a node is zero.

Mathematical Form	Example Application
$\Sigma I = 0$	At node: $I_1 - I_2 - I_3 + I_4 = 0$
$\Sigma I_{in} = \Sigma I_{out}$	Currents entering = Currents leaving

### Mnemonic

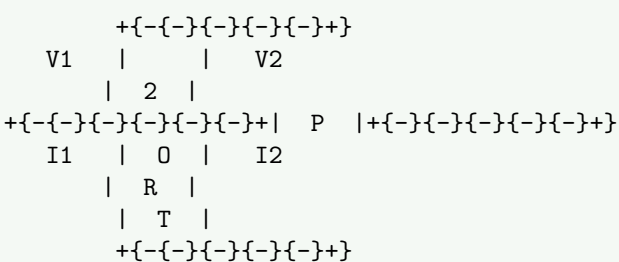
“ZINC” - Zero Is Net Current at a node

Question 2(b) [4 marks]

Explain Z-parameter, Y-parameter, h-parameter and ABCD-parameter using suitable network.

## Solution

Diagram:



Parameter	Definition	Equations	Usage
<b>Z</b>	Impedance parameters	$V_1 = Z_{11}I_1 + Z_{12}I_2, V_2 = Z_{21}I_1 + Z_{22}I_2$	High impedance circuits
<b>Y</b>	Admittance parameters	$I_1 = Y_{11}V_1 + Y_{12}V_2, I_2 = Y_{21}V_1 + Y_{22}V_2$	Low impedance circuits
<b>h</b>	Hybrid parameters	$V_1 = h_{11}I_1 + h_{12}V_2, I_2 = h_{21}I_1 + h_{22}V_2$	Transistor circuits
<b>ABCD</b>	Transmission parameters	$V_1 = AV_2 - BI_2, I_1 = CV_2 - DI_2$	Cascaded networks

### Mnemonic

“ZANY HAB” - Z for high impedance, A for low, hy-brid for transistors, ABCD for Cascades

Question 2(c) [7 marks]

Derive the equations to convert  $\pi$ -type network into T-type network and T-type network into  $\pi$ -type network.

## Solution

**Diagram:**

### Mermaid Diagram (Code)

```

{Shaded}
{Highlighting}[]
graph TD
    subgraph T{-Network}
        A1((1)) --{-} Z1 --{-}{-}{-} O1((0))
        B1((2)) --{-} Z2 --{-}{-}{-} O1
        C1((3)) --{-} Z3 --{-}{-}{-} O1
    end

    subgraph {-Network}
        A2((1)) --{-} Y1 --{-}{-}{-} B2((2))
        B2 --{-} Y2 --{-}{-}{-} C2((3))
        C2 --{-} Y3 --{-}{-}{-} A2
    end
{Highlighting}
{Shaded}

```

Conversion	Formulas
<b>to T</b>	$Z_1 = (Z_{12}Z_{31}) / (Z_{12} + Z_{23} + Z_{31})$ $Z_2 = (Z_{12}Z_{23}) / (Z_{12} + Z_{23} + Z_{31})$ $Z_3 = (Z_{23}Z_{31}) / (Z_{12} + Z_{23} + Z_{31})$
<b>T to</b>	$Z_{12} = (Z_1Z_2 + Z_2Z_3 + Z_3Z_1) / Z_3$ $Z_{23} = (Z_1Z_2 + Z_2Z_3 + Z_3Z_1) / Z_2$ $Z_{31} = (Z_1Z_2 + Z_2Z_3 + Z_3Z_1) / Z_1$

- **Application:** Network simplification and analysis
- **Condition:** Both networks must be equivalent at terminals
- **Limitation:** Only applies for linear networks

### Mnemonic

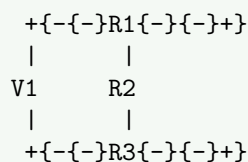
“TRIP” - T and networks Relate Impedances through Products and sums

## Question 2(a OR) [3 marks]

Explain KVL with example.

### Solution

Diagram:



**Kirchhoff's Voltage Law (KVL):** The algebraic sum of all voltages around any closed loop is zero.

Mathematical Form	Example Application
$\sum V = 0$	In loop: $V_1 - IR_1 - IR_2 - IR_3 = 0$
$\sum V_{\text{rises}} = \sum V_{\text{drops}}$	Voltage rises = Voltage drops

### Mnemonic

“ZERO” - Zero is Every voltage Round a loop's Output

## Question 2(b OR) [4 marks]

Classify and explain various Electronics network.

## Solution

Network Type	Description	Example
<b>Linear vs Non-linear</b>	Follows/doesn't follow proportionality principle	Resistors vs Diodes
<b>Passive vs Active</b>	Don't/do supply energy	RC circuit vs Amplifier
<b>Bilateral vs Unilateral</b>	Same/different properties in either direction	Resistors vs Diodes
<b>Lumped vs Distributed</b>	Parameters concentrated/spread	RC circuit vs Transmission line
<b>Time variant vs Invariant</b>	Parameters change/don't change with time	Electronic switch vs Fixed resistor

### Diagram:

graph TB

```

A[Electronic Networks]
A --> B[Based on Linearity]
A --> C[Based on Energy]
A --> D[Based on Directionality]
A --> E[Based on Parameters]
A --> F[Based on Time]

B --> G[Linear]
B --> H[Non-linear]
C --> I[Active]
C --> J[Passive]
D --> K[Bilateral]
D --> L[Unilateral]
E --> M[Lumped]
E --> N[Distributed]
F --> O[Time-invariant]
F --> P[Time-variant]

```

## Mnemonic

“PLANT” - Proportionality for Linear, Lively for Active, All directions for bilateral, Near for lumped, Time-fixed for invariant

## Question 2(c OR) [7 marks]

Derive the equation of characteristic impedance for T-network and  $\pi$ -network.

## Solution

### Diagram:

#### Mermaid Diagram (Code)

```

{Shaded}
{Highlighting}[]
graph TD
    subgraph T-Network
        A1((1)) --> Z1 --> O1((0))
        O1 --> Z3 --> C1((2))
        O1 --> Z2 --> B1
    end

    subgraph pi-Network
        A2((1)) --> Y1 --> B2
        B2 --> Y2 --> C2((2))
    end

```

```

C2 {-{-} Y3 {-}{-}{-} A2}
end
{Highlighting}
{Shaded}

```

Network	Characteristic Impedance Equation	Derivation Steps
<b>T-Network</b>	$Z_0 T = \sqrt{(Z_1 + Z_2)(Z_2 + Z_3)}$	1. Apply symmetrical load $Z_0$ 2. Find input impedance 3. For impedance $Z_0$ 4. Solve for $Z_0$
<b>-Network</b>	$Z_0 = 1 / \sqrt{(Y_1 + Y_3)(Y_2 + Y_3)}$	1. Apply symmetrical load $Z_0$ 2. Find input impedance 3. For impedance $Z_0$ 4. Solve for $Z_0$

- **Relation:**  $Z_0 T \times Z_0 = Z_1 Z_3$
- **Application:** Impedance matching and filters
- **Limitation:** Valid only for symmetrical networks

### Mnemonic

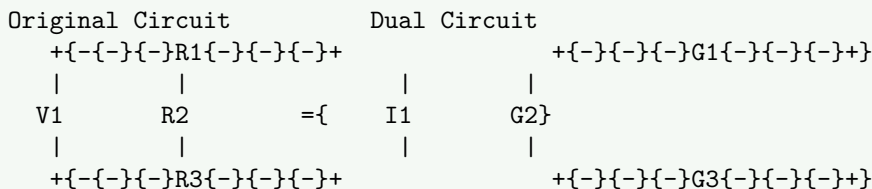
“TIPSZ” - T-networks and -networks Impedances are Products and Square roots of Z values

### Question 3(a) [3 marks]

Explain the principle of duality with example.

#### Solution

##### Diagram:



**Principle of Duality:** For every electrical network, there exists a dual network where:

Original	Dual	Example
Voltage (V)	Current (I)	10V source $\rightarrow$ 10A source
Current (I)	Voltage (V)	5A $\rightarrow$ 5V
Resistance (R)	Conductance (G)	100 $\Omega$ $\rightarrow$ 100S
Series connection	Parallel connection	Series resistors $\rightarrow$ Parallel conductors
KVL	KCL	$\Sigma V = 0 \rightarrow I = 0$

### Mnemonic

“VIGOR” - Voltage to current, Impedance to admittance, Graph remains, Open to closed, Resistors to conductors

### Question 3(b) [4 marks]

Explain the steps to calculate the load current in the circuit using Thevenin's Theorem.

### Solution

#### Diagram:

flowchart LR

```
A[Original Circuit] --> B[Remove Load]
B --> C[Find Voc]
B --> D[Find Rth]
C --> E[Thevenin Equivalent]
D --> E
E --> F[Reconnect Load]
F --> G[Calculate IL = Vth/Rth+RL]
```

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Step	Description
1	Remove the load resistor from the circuit
2	Find open-circuit voltage ( $V_{th}$ ) across load terminals
3	Calculate Thevenin resistance ( $R_{th}$ ) looking back into circuit
4	Draw Thevenin equivalent circuit ( $V_{th}$ in series with $R_{th}$ )
5	Reconnect load resistor ( $R_L$ ) to Thevenin circuit
6	Calculate load current: $I_L = V_{th}/(R_{th}+R_L)$

### Mnemonic

“REVOLT” - Remove load, Evaluate Voc, Obtain  $R_{th}$ , Look at Thevenin circuit, Use  $I = V/R$  formula

### Question 3(c) [7 marks]

Find the current through load resistor using superposition theorem.

### Solution

#### Diagram:

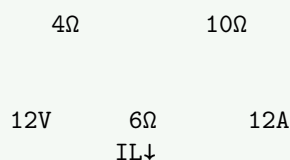


Table 1: Step-by-Step Solution:

Step	Description	Calculation
1	Consider 12V source only (replace 12A with open)	$I_1 = 12/(4 + 6 + 10) = 0.6A$ $I_{1\text{ through }6} = 0.6A$
2	Consider 12A source only (replace 12V with short)	$I_2 = -12 \times 10/(4 + 10 + 6) = -6A$ $I_{2\text{ through }6} = -12 \times 4/(4 + 10 + 6) = -2.4A$
3	Apply superposition	$I_L = I_1 + I_2 = 0.6 + (-2.4) = -1.8A$

### Solution

$I_L = -1.8A$  (current flowing upward through  $6\Omega$  load resistor)

### Mnemonic

“SONAR” - Sources Only one at a time, Neutralize others, Add Results



### Question 3(a OR) [3 marks]

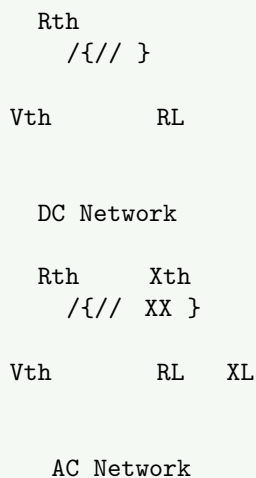
Write Maximum Power Transfer Theorem statement. What are the conditions for maximum power transfer for AC and DC networks?

#### Solution

**Maximum Power Transfer Theorem:** Maximum power is transferred from source to load when the load impedance is equal to the complex conjugate of the source internal impedance.

Network Type	Condition for Maximum Power Transfer
DC Networks	$R_L = R_{th}$ (Load resistance equals Thevenin resistance)
AC Networks	$Z_L = Z_{th}^*$ (Load impedance equals complex conjugate of Thevenin impedance) $R_L = R_{th}$ and $X_L = -X_{th}$

#### Diagram:



#### Mnemonic

“MATCH” - Maximum power At Terminals when Conjugate impedances are Honored

### Question 3(b OR) [4 marks]

Explain the steps to calculate the load current in the circuit using Norton's Theorem.

#### Solution

#### Diagram:

```

flowchart LR
    A[Original Circuit] --> B[Short Load Terminals]
    B --> C[Find Isc]
    C --> D[Find Rn=Rth]
    D --> E[Norton Equivalent]
    E --> F[Reconnect Load]
    F --> G[Calculate IL = In/Rn+RL]
    style E fill:#bbf,stroke:#333
  
```

Step	Description
1	Remove the load resistor from the circuit
2	Find short-circuit current ( $I_n$ ) across load terminals
3	Calculate Norton resistance ( $R_n$ ) looking back into circuit
4	Draw Norton equivalent circuit ( $I_n$ in parallel with $R_n$ )

- 5 Reconnect load resistor (RL) to Norton circuit
- 6 Calculate load current:  $I_L = I_n / (R_n + R_L)$

#### Mnemonic

“SENIOR” - Short terminals, Evaluate  $I_{sc}$ , Notice  $R_n$  value, Implement Norton circuit, Obtain result

### Question 3(c OR) [7 marks]

Demonstrate how the reciprocity theorem is applied to a given network.

#### Solution

Diagram:

$2\Omega$        $2\Omega$   
 $10V$      $4\Omega$      $2\Omega$

Table 2: Applying Reciprocity Theorem:

Step	Circuit 1	Circuit 2	Verification
1	10V source at left, Find $I_1$ at right	10V source at right, Find $I_2$ at left	$I_1 = I_2$ confirms reciprocity
2	Create mesh equations using KVL	Create new mesh equations for swapped source	Solve both systems
3	$I_1 = 10 \times 2 / (2 \times 4 + 2 \times 2 + 4 \times 2) = 0.625A$	$I_2 = 10 \times 2 / (2 \times 4 + 2 \times 2 + 4 \times 2) = 0.625A$	$I_1 = I_2 = 0.625A$

**Principle:** In a passive network containing only bilateral elements, if voltage source E in branch 1 produces current I in branch 2, then the same voltage source E placed in branch 2 will produce the same current I in branch 1.

#### Mnemonic

“RESPECT” - Rewire sources, Exchange positions, See if currents Preserve Equality when Circuit Transformed

### Question 4(a) [3 marks]

Explain coupled circuit.

#### Solution

Diagram:

$L_1$        $L_2$   
 0000    0000  
 $V_1$        $R_L$   
         M  
 Primary    Secondary

**Coupled Circuit:** A circuit where energy is transferred between inductors through mutual inductance.

Parameter	Description
<b>Mutual Inductance (M)</b>	Measure of magnetic coupling between coils

Coupling Coefficient (k)

$k = \frac{M}{\sqrt{L_1 L_2}}$ , ranges from 0 (no coupling) to 1 (perfect coupling)  
Transformers, filters, tuned circuits

#### Mnemonic

“MICE” - Mutual Inductance Creates Energy transfer

### Question 4(b) [4 marks]

Derive the equation of co-efficient of coupling for coupled circuit.

#### Solution

Diagram:

#### Mermaid Diagram (Code)

```
{Shaded}
{Highlighting} []
graph LR
    A[Magnetic Flux Linkage] --{} B[Mutual Inductance]
    B --{} C[Coupling Coefficient]

    subgraph Formula Derivation
        D[" $\Phi_{12} = \text{Flux from coil 1 to 2}$ "]
        E[" $M = N_2 \cdot \Phi_{12} / I_1$ "]
        F[" $k = M / (L_1 \cdot L_2)$ "]
    end
    end
{Highlighting}
{Shaded}
```

Step	Description	Equation
1	Define mutual inductance	$M = N_{212} / I_1$
2	Define self-inductances	$L_1 = N_{111} / I_1, L_2 = N_{222} / I_2$
3	Maximum possible M	$M_{\max} = \sqrt{L_1 L_2}$
4	Define coupling coefficient	$k = M / \sqrt{L_1 L_2}$

- **Range:**  $0 \leq k \leq 1$
- **Physical meaning:** Fraction of flux from one coil linking with the other coil
- **Perfect coupling:**  $k = 1$ , when all flux links both coils

#### Mnemonic

“MASK” - Mutual inductance And Self inductances create K

### Question 4(c) [7 marks]

$R = 20\Omega$ ,

$L = 1H$ ,

$C = 1F$ . Derive equation of resonance frequency for series resonance. Calculate resonant frequency, Q factor and bandwidth of series RLC circuit with

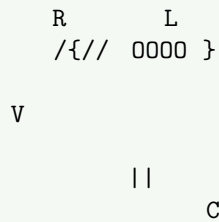
$R = 20\Omega$ ,

$L = 1H$ ,

$C = 1F$ .

## Solution

Diagram:



Derivation:

Step	Description	Equation
1	Impedance of series RLC	$Z = R + j(L - 1/C)$
2	At resonance, $\text{Im}(Z) = 0$	$L - 1/C = 0$
3	Solve for resonant frequency	$f_0 = 1/\sqrt{LC}$ or $f_0 = 1/(2\sqrt{LC})$

Calculations:

Parameter	Formula	Calculation	Result
Resonant frequency	$f_0 = 1/(2\sqrt{LC})$	$f_0 = 1/(2\sqrt{1 \times 10^{-6}})$	159.15 Hz
Q factor	$Q = \omega L/R$	$Q = 2 \times 159.15 \times 1/20$	50
Bandwidth	$BW = f_0/Q$	$BW = 159.15/50$	3.18 Hz

## Mnemonic

“FQBR” - Frequency from reactances, Q from resistance ratio, Bandwidth from Resonance divided by Q

## Question 4(a OR) [3 marks]

Explain Quality factor.

## Solution

Diagram:

Mermaid Diagram (Code)

```

{Shaded}
{Highlighting}[]
graph TD
    A[Quality Factor] --> B[Energy Storage]
    A --> C[Power Loss]
    A --> D[Selectivity]
    A --> E[Bandwidth]

    style A fill:#bbf,stroke:#333
{Highlighting}
{Shaded}
  
```

**Quality Factor (Q):** A dimensionless parameter that indicates how under-damped a resonator is, or alternatively, characterizes a resonator's bandwidth relative to its center frequency.

Definition	Mathematical Expression
Energy perspective	$Q = 2 \times \text{Energy stored} / \text{Energy dissipated per cycle}$
Circuit perspective	$Q = X/R$ (where X is reactance, R is resistance)
Frequency perspective	$Q = f_0/BW$ (where $f_0$ is resonant frequency, BW is bandwidth)

### Mnemonic

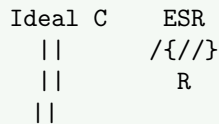
“QSEL” - Quality shows Energy vs. Loss and Selectivity

### Question 4(b OR) [4 marks]

Derive the equation of quality factor for a capacitor.

#### Solution

Diagram:



Real capacitor model

Derivation:

Step	Description	Equation
1	Define energy stored	$E_{\text{stored}} = CV^2/2$
2	Define energy loss per cycle	$E_{\text{loss}} = CV^2/CR = V^2/R$
3	Define Q factor	$Q = 2 \times E_{\text{stored}}/E_{\text{loss}}$
4	Substitute and simplify	$Q = 2 \times (CV^2/2) \div (V^2/R) = CR$

Final equation:  $Q = CR = 1/(\omega R) = 1/\tan \delta$

Where:

- $\omega$  = Angular frequency ( $2\pi f$ )
- R = Equivalent series resistance (ESR)
- C = Capacitance
- $\tan \delta$  = Dissipation factor

### Mnemonic

“CORE” - Capacitors’ Quality equals One over Resistance times Capacitance

### Question 4(c OR) [7 marks]

$R=30\Omega$ ,

$L=1H$ ,

$C=1F$ . Derive equation of resonance frequency for parallel resonance. Calculate resonant frequency, Q factor and bandwidth of parallel RLC circuit with

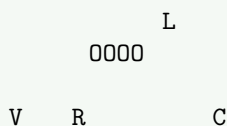
$R=30\Omega$ ,

$L=1H$ ,

$C=1F$ .

#### Solution

Diagram:



Derivation:

Step	Description	Equation
1	Admittance of parallel RLC	$Y = 1/R + 1/jL + jC$
2	At resonance, $\text{Im}(Y) = 0$	$1/jL + jC = 0$
3	Solve for resonant frequency	$0 = 1/\sqrt{LC} \text{ or } f_0 = 1/(2\sqrt{LC})$

Calculations:

Parameter	Formula	Calculation	Result
Resonant frequency	$f_0 = 1/(2\sqrt{LC})$	$f_0 = 1/(2\sqrt{1 \times 10^{-6}})$	<b>159.15 Hz</b>
Q factor	$Q = R/\omega L$	$Q = 30/(2 \times 159.15 \times 1)$	<b>0.03</b>
Bandwidth	$BW = f_0/Q$	$BW = 159.15/0.03$	<b>5305 Hz</b>

### Mnemonic

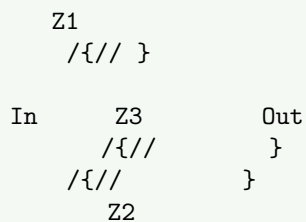
“FPQB” - Frequency from Parallel elements, Q from Resistance divided by reactance, Bandwidth from division

## Question 5(a) [3 marks]

Explain the T type attenuator.

### Solution

Diagram:



**T-type Attenuator:** A passive network in T configuration used to reduce signal amplitude.

Component	Description	Formula
<b>Z1, Z2</b>	Series arms	$Z1 = Z2 = Z_0(N - 1)/(N + 1)$
<b>Z3</b>	Shunt arm	$Z3 = 2Z_0/(N^2 - 1)$
<b>N</b>	Attenuation ratio	$N = 10^{(dB/20)}$

- **Characteristic:** Symmetrical for matched source and load
- **Applications:** Signal level control, impedance matching
- **Advantage:** Maintains impedance matching with proper design

### Mnemonic

“TSAR” - T-shape with Series Arms and Resistance in middle

## Question 5(b) [4 marks]

Classify the various passive filter circuits.

### Solution

Diagram:

Mermaid Diagram (Code)

```

{Shaded}
{Highlighting}[]
graph TD
    A[Passive Filters]
    A --> B[Based on Frequency Response]
    A --> C[Based on Configuration]

    B --> D[Low Pass]
    B --> E[High Pass]
    B --> F[Band Pass]
    B --> G[Band Stop]

    C --> H[T-section]
    C --> I[L-section]
    C --> J[L-section]
    C --> K[Lattice]
{Highlighting}
{Shaded}

```

Filter Type	Function	Typical Circuit	Applications
Low Pass	Passes low frequencies	RC, RL circuits	Audio filters, Power supplies
High Pass	Passes high frequencies	CR, LR circuits	Noise filtering, Signal conditioning
Band Pass	Passes a band of frequencies	RLC circuits	Radio tuning, Signal selection
Band Stop	Blocks a band of frequencies	Parallel RLC	Interference rejection

### Mnemonic

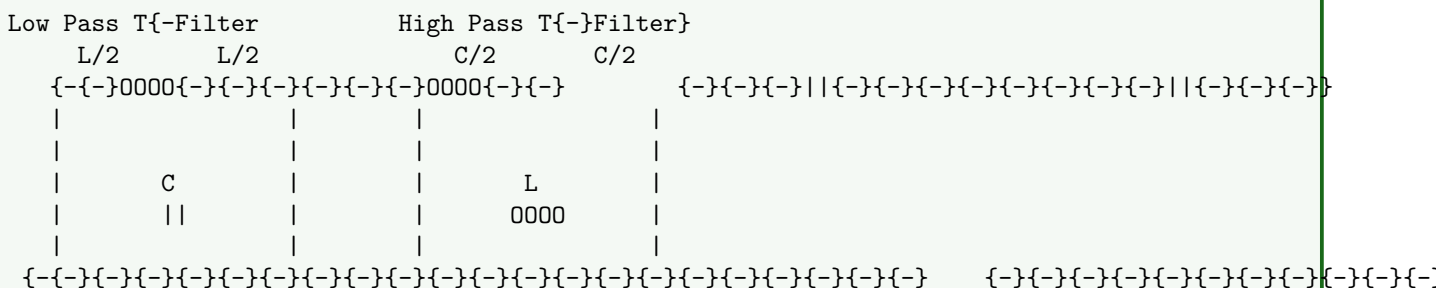
“LHBB” - Low High Band Band filters for Pass and Block

### Question 5(c) [7 marks]

Design constant-k type low pass and High pass filter with T-section having cutoff frequency= 1000Hz & load of 500Ω.

### Solution

Diagram:



Design Calculations:

For Constant-k T-type low pass filter:

Parameter	Formula	Calculation	Value
Cut-off frequency	$f_c = 1000 \text{ Hz}$	Given	1000 Hz
Load impedance	$R_0 = 500$	Given	500 Ω
Series inductor	$L = R_0 / f_c$	$L = 500 / ( \times 1000 )$	159.15 mH
Half sections	$L/2$	159.15/2	79.58 mH

Shunt capacitor  $C = 1/(f_c R_0)$   $C = 1/(\times 1000 \times 500)$  **0.636 F**

For Constant-k T-type high pass filter:

Parameter	Formula	Calculation	Value
Series capacitor	$C = 1/(4 f_c R_0)$	$C = 1/(4 \times 1000 \times 500)$	<b>0.159 F</b>
Half sections	$C/2$	$0.159/2$	<b>0.0795 F</b>
Shunt inductor	$L = R_0/(4 f_c)$	$L = 500/(4 \times 1000)$	<b>39.79 mH</b>

### Mnemonic

“FRED” - Frequency Ratio determines Element Dimensions

### Question 5(a OR) [3 marks]

Explain the  $\pi$  type attenuator.

#### Solution

Diagram:

$Z_2$

In  $Z_1$   $Z_3$  Out

$\pi$ -type Attenuator: A passive network in  $\pi$  configuration used to reduce signal amplitude.

Component	Description	Formula
$Z_2$	Series arm	$Z_2 = 2Z_0/(N^2 - 1)$
$Z_1, Z_3$	Shunt arms	$Z_1 = Z_3 = Z_0(N + 1)/(N - 1)$
N	Attenuation ratio	$N = 10^{(dB/20)}$

- Characteristic: Symmetrical for matched source and load
- Applications: Signal level control, impedance matching
- Advantage: Good isolation between input and output

### Mnemonic

“PASS” - Pi-Attenuator has Series in middle and Shunt arms outside

### Question 5(b OR) [4 marks]

Classify various types of attenuators.

#### Solution

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Attenuators]
    A --> B[Based on Structure]
```



```

A {-}{-}{ } C[Based on Function]}

B {-}{-}{ } D[T{-}type]}
B {-}{-}{ } E[ {-}type]}
B {-}{-}{ } F[L{-}type]}
B {-}{-}{ } G[Bridged{-}T]}
B {-}{-}{ } H[Lattice]}

C {-}{-}{ } I[Fixed]}
C {-}{-}{ } J[Variable]}
C {-}{-}{ } K[Stepped]}
C {-}{-}{ } L[Programmable]}
{Highlighting}
{Shaded}

```

Attenuator Type	Characteristics	Applications	Advantages
T-type	Series-Shunt-Series	Audio systems	Simple design
-type	Shunt-Series-Shunt	RF circuits	Better isolation
L-type	Series-Shunt	Simple matching	Impedance transformation
Bridged-T	Balanced structure	Test equipment	Minimal distortion
Balanced	Symmetric dual paths	Differential signals	Common mode rejection

#### Mnemonic

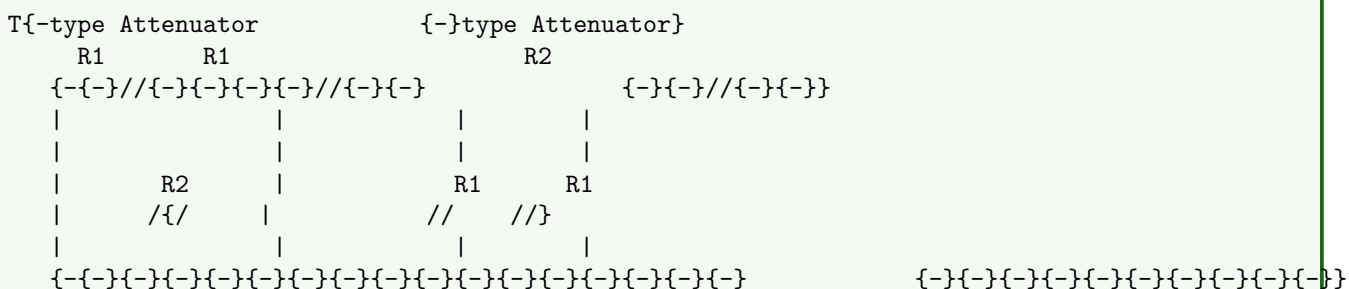
“TPLBV” - T, Pi, L, Bridged-T, and Variable attenuators

#### Question 5(c OR) [7 marks]

Design a symmetrical T type attenuator and  $\pi$  type attenuator to give attenuation of 40dB and to work into the load of  $500\Omega$ .

#### Solution

##### Diagram:



##### Design Calculations:

Step	Formula	Calculation	Value
Given	Attenuation = 40 dB	-	40 dB
Step 1	$N = 10^{(dB/20)}$	$10^{(40/20)}$	100
Step 2	$K = (N-1)/(N+1)$	$(100-1)/(100+1)$	0.98

For T-type attenuator:

Component	Formula	Calculation	Value
$R_1(\text{series})$	$Z_0 K$	$500 \times 0.98$	$490 \Omega$
$R_2(\text{shunt})$	$Z_0 / (K(N - K))$	$500 / (0.98 \times (100 - 0.98))$	$5.15 \Omega$

For  $\pi$ -type attenuator:

Component	Formula	Calculation	Value
$R_1(\text{shunt})$	$Z_0 / K$	$500 / 0.98$	$510.2 \Omega$
$R_2(\text{series})$	$Z_0 K(N - K)$	$500 \times 0.98 \times (100 - 0.98)$	$48,541 \Omega$

#### Mnemonic

“DANK” - dB Attenuation is Number K, which determines resistor values