

Scilab Textbook Companion for
Fluid Systems (fluid Machines)
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Book Description

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Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

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Chapter 2

Impact of Jet

Scilab code Exa 2.1 To Find the Force exerted by the Jet of water

```
1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.1
4     clc
5     clear
6
7 //Given Data:–
8     V=32;           //Velocity of the Jet, m/s
9     d=5;           //Diameter of the Jet, cm
10
11 //Data Used:–
12     rho=1000;      //Density of water, kg/m^3
13
14 //Computations:–
15     d=d/100;       //cm
16     a=(%pi/4)*d^2; //cross-sectional area of
17                   //Jet, m^2
18     m=rho*a*V;     //Mass Flow Rate, kg/s
19     F=m*V/1000;    //Force Exerted by the Jet
20                   //on the flat plate, kN
21 //Result:–
```

```

20     printf("The Force exerted by the Jet on the
        plate=%0.3f kN \n", F)           //The answer vary
        due to round off error

```

Scilab code Exa 2.2 To Determine a The Maximum force of the Jet on the plate b Com

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.2
4     clc
5     clear
6
7 //Given Data:–
8     V=25;           //Velocity of the Jet, m/s
9     theta=45;      //Inclination of the plate
                    //with Jet axis, degrees
10    a=30;           //cross-sectional area of the Jet,
                    //cm^2
11
12 //Data Used:–
13    rho=1000;      //Density of water, kg/m^3
14
15 //Computations:–
16    a=a*10^-4;     //m^2
17    //(a) Force normal to the plate is the
                    //maximum force of Jet on the plate Fn
18    Fn=rho*a*V^2*sind(theta); //N
19    //(b) Components of the force Fn,
20    Fx=Fn*sind(theta); //N
21    Fy=Fn*cosd(theta); //N
22    //(c) Ratio in which the discharge gets
                    //divided
23    Q1_by_Q2=(1+cosd(theta))/(1-cosd(theta));
24 //Results:–
25    printf("(a)The Maximum force of the Jet on the

```

```

        plate , Fn=%.2f N \n", Fn)          //The
        answer vary due to round off error
26  printf("(b)Components of the Normal force , Fn
        are: \n\t")
27  printf("Fx=%.2f N    ,   Fy=%.2f N \n", Fx, Fy)
        //The answer vary due to round off
        error
28  printf("(C)The Ratio in which discharge gets
        divided , Q1/Q2=%.2f \n", Q1_by_Q2)    //
        The answer vary due to round off error

```

Scilab code Exa 2.3 To Find the force exerted by the Jet of water in the direction

```

1  //Fluid system – By – Shiv Kumar
2  //Chapter 2 – Impact of Jet
3  //Example 2.3
4      clc
5      clear
6  //Given Data:–
7      d=40;      //Diameter of the Jet , mm
8      V=60;      //Velocity of the Jet , m/s
9      AoD=125;   //Angle of Deflection , degrees
10
11 //Data Used:–
12     rho=1000;   //Density of water , kg/m^3
13
14 //Computations:–
15     d=d/1000;   //m
16     a=(%pi/4)*d^2; //cross-sectional area
        of Jet , m^2
17     theta=180-AoD; //degrees
18     Fx=rho*a*V^2*(1+cosd(theta)); //N
19 //Results:–
20     printf("The Force exerted by the Jet of water
        in the direction of Jet , Fx=%.2f N \n",Fx)

```

//The answer provided in the textbook
is wrong.

Scilab code Exa 2.4 To Find the force exerted by the Jet on the plate in the Horiz

```
1
2 //Fluid system – By – Shiv Kumar
3 //Chapter 2 – Impact of Jet
4 //Example 2.4
5     clc
6     clear
7
8 //Given Data:–
9     d=65;           //Diameter of the Jet, mm
10    V=45;           //Velocity of the Jet, m/s
11    theta_i=35;     //Entry angle with
                    //horizontal, degrees
12    theta_o=25;     //Exit angle with horizontal
                    //degrees
13
14 //Data Used:–
15    rho=1000;       //Density of water, kg/m^3
16
17 //Computations:–
18    d=d/1000;       //m
19    a=(%pi/4)*d^2;  //cross-sectional area
                    //of Jet, m^2
20    Fx=rho*a*V^2*(cosd(theta_i)+cosd(theta_o));
                    //N
21    Fy=rho*a*V^2*(sind(theta_i)-sind(theta_o));
                    //N
22 //Results:–
23    printf("Force exerted by Jet in horizontal
           direction, Fx=%0.2f N \n", Fx)           //The
           answer provided in the textbook is wrong
```

```

24     printf("Force exerted by Jet in vertical
           direction , Fy=%.3f N(Fy acts upward) or Fy=-
           %.3f N(Fy acts downward) \n", Fy, Fy)
           //The answer vary due to round off error

```

Scilab code Exa 2.5 To Find the Angle through which the plate will swing

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.5
4     clc
5     clear
6
7 //Given Data:–
8     d=30; //Diameter of the Jet, mm
9     V=15; //Velocity of the Jet, m/s
10    W=245.25; //Weight of plate, N
11
12 //Data Used:–
13    rho=1000; //Density of water, kg/m^3
14
15 //Computations:–
16    d=d/1000; //m
17    a=(%pi/4)*d^2; //cross-sectional area
           of Jet, m^2
18    theta=asind(rho*a*V^2/W); //degrees
19 //Results:–
20    printf("The Angle through which the plate will
           swing, theta=%.2f degrees \n", theta)
           //The answer vary due to round off error

```

Scilab code Exa 2.6 To a Find the force applied at lower edge of plate to keep it

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.6
4     clc
5     clear
6 //Given Data:–
7     M=13.5;      //Mass of plate , kg
8     d=16;       //Diameter of the Jet , mm
9     V=20;       //Velocity of the Jet , m/s
10    L=300;      //Length of Edge of plate , mm
11
12 //Data Used:–
13    rho=1000;    //Density of water , kg/m^3
14    g=9.81;     //Acceleration due to gravity , m/
15                s^2
16 //Computations:–
17    d=d/1000;   //m
18    L=L/1000;   //m
19    W=M*g;      //Weight of Plate , N
20    a=(%pi/4)*d^2; //cross sectional area of
21                Jet , m^2
22 // (a)
23    Fx=rho*a*V^2; //Force exerted by Jet
24                normal to plate , N
25 //Taking Moment at 'A',
26    P=Fx*(L/2)/L; //N
27 // (b)
28    theta=asind(rho*a*V^2/W); //Angle of
29                Swing , degrees
30 //Results:–
31    printf("(a) Horizontal force applied at Lower
32            edge of plate to keep it vertical , P=%0.3f N
33            \n", P) //The answer vary due to round
34                off error
35    printf("(b) Angle of swing , theta=%0.2f degrees",
36            theta) //The answer vary due to round
37                off error

```

Scilab code Exa 2.7 To a Find the horizontal force applied at centre of gravity to

```
1 //Fluid system - By - Shiv Kumar
2 //Chapter 2 - Impact of Jet
3 //Example 2.7
4
5     clc
6     clear
7
8 //Given Data:-
9     W=55.50; //Weight of plate , N
10    V=8; //Velocity of the Jet , m/s
11    d=22; //Diameter of the Jet , mm
12    AG=125; //Distance between centre of
           gravity of plate from hinge , mm
13    AC=150; //Distance between axis of Jet
           and hinge , mm
14    theta=35; //Deflection , degrees
15
16 //Data Used:-
17    rho=1000; //Density of water , kg/m^3
18
19 //Computations:-
20    d=d/1000; //m
21    AC=AC/1000; //m
22    AG=AG/1000; //m
23    a=(%pi/4)*d^2; //cross sectional area of
           Jet , m^2
24    Fx=rho*a*V^2; //N
25 //Taking moment about hinge point 'A',
26    P=Fx*AC/AG; //N
27    Fn=(W*AG*sind(theta)+P*AG*cosd(theta))/(AC/
           cosd(theta)); //N
28    V1=sqrt(Fn/(rho*a*cosd(theta))); //
```



```

                Absolute Velocity of Jet , m/s
29      velocity_increase=V1-V;          //Velocity
        Increase of the Jet , m/s
30
31 //Results:-
32      printf("(a)Horizontal force applied at centre
        of gravity to maintain the plate in vertical
        position , P=%0.3f N \n", P)      //The
        answer vary due to round off error
33      printf("(b)Increase in velocity of Jet=%0.3f m/s
        ", velocity_increase)          //The answer vary
        due to round off error

```

Scilab code Exa 2.8 To Find a the Force exerted by the Jet on the plate b Work don

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.8
4      clc
5      clear
6
7 //Given Data:-
8      d=75;          //Diameter of the Jet , mm
9      V=14;         //Velocity of the Jet , m/s
10     u=5;          //Velocity of plate , m/s
11
12 //Data Used:-
13     rho=1000;     //Density of water , kg/m^3
14
15 //Computations:-
16     d=d/1000;    //m
17     a=(%pi/4)*d^2; //cross sectional area of
        Jet , m^2
18     F=rho*a*(V-u)^2; //N
19     W=F*u;      //J/s

```

```

20         KE=(1/2)*rho*a*V^3;           //N-m/s
21         eta=W/KE*100;                 //In percentage
22
23 //Results:-
24     printf("(a)The Force exerted by the Jet on the
        plate , F=%0.2f N \n", F)       //The answer
        vary due to round off error
25     printf("(b)Work done by the Jet on the plate
        per second=%0.1f N-m/s or J/s \n", W)
        //The answer vary due to round off error
26     printf("(c)Efficiency of Jet , eta=%0.2f percent"
        , eta)                          //The answer vary due to round
        off error

```

Scilab code Exa 2.9 To Find a Force exerted on the plate in the direction of Jet b

```

1 //Fluid system - By - Shiv Kumar
2 //Chapter 2 - Impact of Jet
3 //Example 2.9
4     clc
5     clear
6
7 //Given Data:-
8     d=65;           //Diameter of the Jet , mm
9     V=20;           //Velocity of the Jet , m/s
10    u=8;             //Velocity of curved vane , m/s
11    AoD=160;        //Angle of Deflection , degrees
12
13 //Data Used:-
14    rho=1000;       //Density of water , kg/m^3
15
16 //Computations:-
17    d=d/1000;       //m
18    a=(%pi/4)*d^2; //cross-sectional area
        of Jet , m^2

```

```

19         theta=180-AoD;           //degrees
20         Fx=rho*a*(V-u)^2*(1+cosd(theta));           //N
21         P=Fx*u/1000;           //Power of Jet , KW
22         KE=(1/2)*rho*a*V^3;           //Kinetic energy of
           Jet per second , N-m/s(W)
23         eta=P*1000/KE*100;           //In percentage
24
25 //Results:-
26         printf("(a)The Force exerted on plate in
           direction of Jet , Fx=%0.2f N \n", Fx)
           //The answer vary due to round off error
27         printf("(b)Power of Jet=%0.3f KW \n", P)
           //The answer vary due to round off error
28         printf("(c)Efficiency of Jet , eta=%0.2f percent"
           , eta)

```

Scilab code Exa 2.10 To Calculate the magnitude and direction of the Resultant Force

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.10
4     clc
5     clear
6 //Given Data:-
7     V1=40;           //Velocity of the Jet at Inlet , m
           /s
8     V2=32;           //Velocity of the Jet at Outlet ,
           m/s
9     theta=65;           //Angle of Deflection from
           original direction , degrees
10    m=0.9;           //Mass flow rate , kg/s
11
12 //Computations:-
13    Fx=m*(V1-V2*cosd(theta));           //N (
           Answer in textbook is wrong)

```

```

14         Fy=m*V2*sind(theta);           //N
15         F_R=sqrt(Fx^2+Fy^2);           //Resultant Force,
           N
16         phi=atand(Fy/Fx);              //Angle made by
           resultant with X-axis, degrees
17
18 //Results:-
19         printf("Resultant Force, F_R=%0.2f N at an angle
           , phi=%0.2f Degrees to X-axis", F_R, phi)
           //The answer provided in the textbook
           is wrong

```

Scilab code Exa 2.11 a To Determine the components of force acting on Vane in dire

```

1 //Fluid system - By - Shiv Kumar
2 //Chapter 2 - Impact of Jet
3 //Example 2.11
4         clc
5         clear
6 //Given Data:-
7         //(a)
8         V=60;           //Velocity of the Jet, m/s
9         theta=30;      //Angle of Outlet, degrees
10        //(b)
11        u=25;           //Velocity of vane, m/s
12
13
14 //Data Used:-
15        g=9.81;        //Acceleration due to gravity, m/s
           ^2
16
17 //Computations:-
18        //(a)
19        Fx=(V/g)*(1+cosd(theta));        //Force
           exerted by Unit weight of water in

```

```

    direction of Jet , N/N of Water
20     Fy=V*sind(theta)/g; //Force exerted by Unit
        weight of water in direction
        perpendicular to direction of Jet , N/N of
        Water
21     F_R=sqrt(Fx^2+Fy^2); //Resultant for per
        unit weight of water , N/N of Water
22     phi=atand(Fy/Fx); //Angle made by
        resultant with X-axis , degrees
23
24 //Results(a):-
25     printf("(a)\nForce exerted by Unit weight of
        water in direction of Jet , Fx=%.2f N/N of
        Water \n" , Fx)
26     printf("Force exerted by Unit weight of water
        in direction perpendicular to direction of
        Jet , Fy=%.2f N/N of water \n" , Fy) //
        The answer vary due to round off error
27     printf("Resulatant Force , F_R=%.2f N/N of Water
        at angle , phi=%.2f degrees \n\n" , F_R , phi)
        //The answer vary due to round off
        error
28 // (b)
29     Fx=(V-u)*(1+cosd(theta))/g; //Force
        exerted by Unit weight of water in
        direction of Jet , N/N of Water
30     Fy=(V-u)*sind(theta)/g; //Force
        exerted by Unit weight of water in
        direction perpendicular to direction of
        Jet , N/N of Water
31     F_R=sqrt(Fx^2+Fy^2); //Resultant
        force per unit weight of water , N/N of
        Water
32     phi=atand(Fy/Fx); //Angle made
        by resultant with X-axis , degrees
33     W=Fx*u; //N-m/s/N of Water
34     P=Fx*u/1000; //Power developed per
        unit weight of water , KW/N of Water

```

```

35 //Result(b)
36 printf("(b)\nForce exerted by Unit weight of
    water in direction of Jet , Fx=%0.2f N/N of
    Water \n", Fx) //The answer vary due
    to round off error
37 printf("Force exerted by Unit weight of water
    in direction perpendicular to direction of
    Jet , Fy=%0.2f N/N of water \n", Fy)
38 printf("Resulatant Force , F_R=%0.2f N/N of Water
    at angle , phi=%0.2f degrees \n\n", F_R, phi)
    //The answer vary due to round off
    error
39 printf("Work done per unit weight of water=%0.2f
    N-m/s/N of Water \n", W) //The answer
    vary due to round off error
40 printf("Power developed per unit weight of
    water=%0.4f KW/N of Water", P) //The
    answer vary due to round off error

```

Scilab code Exa 2.12 To Find a Vane angles b Work done per second per unit weight

```

1 //Fluid system - By - Shiv Kumar
2 //Chapter 2 - Impact of Jet
3 //Example 2.12
4     clc
5     clear
6 //Given Data:-
7     Vi=22; //Absolute velocity of Jet at
           Inlet of Vane, m/s
8     u=11; //Velocity of Vane, m/s
9     ui=u;
10    uo=u;
11    alpha_i=25; //Angle made by Jet at
           Inlet , degrees
12    alpha_l=135; //Angle made by Jet at

```

```

13         leaving , degrees
14         alpha_o=180-alpha_l;           //degrees
15 //Data Used:-
16     g=9.81;           //Acceleration due to gravity , m/
17         s^2
18 //Computations:-
19     //(a)
20         Vwi=Vi*cosd(alpha_i);         //m/s
21         Vfi=Vi*sind(alpha_i);         //m/s
22         Vrwi=Vwi-ui;           //m/s
23         beta_i=atand(Vfi/Vrwi);       //degrees
24         Vri=Vfi/sind(beta_i);        //m/s
25         Vro=Vri;
26         beta_o=alpha_o-asind(uo*sind(180-alpha_o)/
27             Vro);           //degrees
28         Vwo=Vro*cosd(beta_o)-uo;     //degrees
29     //(b)
30         W=(Vwi+Vwo)*u/g;           //N-m/N
31 //Results:-
32     printf("(a)Vane angle at Inlet , beta_i=%0.2f
33         degrees \n", beta_i)       //The answer vary
34         due to round off error
35     printf("    Vane angle at Outlet , beta_o=%0.2f
36         degrees \n", beta_o)       //The answer vary
37         due to round off error
38     printf("(b)Work done per second per unit weight
39         of water striking the vane per second=%0.2f
40         N-m/N", W)           //The answer vary due to
41         round off error

```

Scilab code Exa 2.13 To Find the maximum value of work done and Efficiency

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.13
4     clc
5     clear
6
7 //Given Data:–
8     d=25;           //Diameter of the Jet , mm
9     V=27;           //Velocity of the Jet , m/s
10    AoD=140;        //Angle of Deflection ,
                        degrees
11
12 //Data Used:–
13    rho=1000;       //Density of water , kg/m^3
14
15 //Computations:–
16    d=d/1000;       //m
17    a=(%pi/4)*d^2;  //cross-sectional area of
                        Jet , m^2
18    m=rho*a*V;      //Mass Flow Rate , kg/s
19 //For condition of Maximum work done ,
20    u=V/3;           //Velocity of Vane , m/s
21    theta=180-AoD;  //degrees
22 // (a) Maximum work done/second
23    W=rho*a*(V-u)^2*(1+cosd(theta))*u/1000;
                        //kJ/s
24 // (b) Efficiency of the Jet ,
25    KE=(1/2)*rho*a*V^3; //kinetic energy
                        supplied by jet per second , J
26    eta=W*1000/KE*100; //In percentage
27
28 //Result:–
29    printf("(a)Maximum work done/sec=%0.3f kJ/s \n",
        W) //The answer vary due to round off
        error
30    printf("(b)Effeciency of the Jet , eta=%0.2f
        percent \n", eta) //The answer vary due
        to round off error

```

Scilab code Exa 2.14 To Determine the Vane Angle at Inlet and Outlet

```
1 //Fluid system - By - Shiv Kumar
2 //Chapter 2 - Impact of Jet
3 //Example 2.14
4     clc
5     clear
6 //Given Data:-
7     Vi=50; //Absolute velocity of Jet at
           inlet , m/s
8     u=25; //velocity of vane , m/s
9     ui=u;
10    uo=u;
11    alpha_i=32; //Angle made by Vi at
               inlet , degrees
12    alpha_l=90; //Angle made by Vi at
               outlet , degrees
13    alpha_o=180-alpha_l; //degrees
14
15 //Computations:-
16    Vfi=Vi*sind(alpha_i); //m/s
17    Vwi=Vi*cosd(alpha_i); //m/s
18    Vwi=Vwi-ui; //m/s
19    beta_i=atand(Vfi/Vwi); //degrees
20    Vri=Vfi/sind(beta_i); //m/s
21    Vro=Vri;
22    beta_o=acosd(uo/Vro); //degrees
23
24 //Result:-
25    printf("Vane Angle at Inlet , beta_i=%0.2 f
           degrees \n", beta_i)
26    printf("Vane angle at outlet , beta_o=%0.2 f
           degrees \n", beta_o) //The answer vary
           due to round off error
```

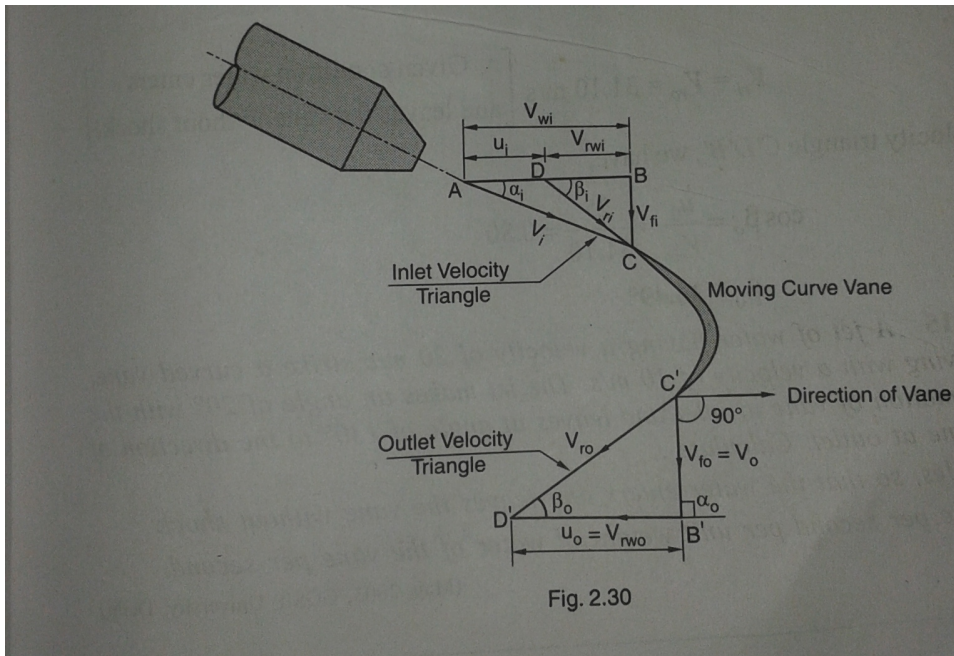


Figure 2.1: To Determine the Vane Angle at Inlet and Outlet

Scilab code Exa 2.15 To Find a Vane angles b Work done per second per unit weight

```

1 //Fluid system - By - Shiv Kumar
2 //Chapter 2 - Impact of Jet
3 //Example 2.15
4     clc
5     clear
6
7 //Given Data:-
8     Vi=20; //Absolute velocity of Jet at
           //Inlet of Vane, m/s
9     u=10; //Velocity of Vane, m/s

```

```

10         ui=u;
11         uo=u;
12         alpha_i=20;           //Angle made by Jet at
           Inlet , degrees
13         alpha_l=130;        //Angle made by Jet at
           leaving , degrees
14         alpha_o=180-alpha_l;           //degrees
15
16 //Data Used:-
17         g=9.81;             //Acceleration due to gravity , m
           /s^2
18
19 //Computations:-
20 // (a)
21         Vwi=Vi*cosd(alpha_i);           //m/s
22         Vfi=Vi*sind(alpha_i);           //m/s
23         Vrwi=Vwi-ui;                   //m/s
24         beta_i=atand(Vfi/Vrwi);           //degrees
25         Vri=Vfi/sind(beta_i);           //m/s
26         Vro=Vri;
27         beta_o=alpha_o-asind(uo*sind(180-alpha_o)/
           Vro);           //degrees
28         Vwo=Vro*cosd(beta_o)-uo;           //degrees
29 // (b)
30         W=(Vwi+Vwo)*u/g;           //N-m/N
31
32 //Results:-
33         printf("(a)Vane angle at Inlet , beta_i=%0.2f
           degrees \n", beta_i)
34         printf("    Vane angle at Outlet , beta_o=%0.2f
           degrees \n\n", beta_o)           //The answer
           vary due to round off error
35         printf("(b)Work done per second per unit weight
           of water striking the vane per second=%0.2f
           N-m/N", W)           //The answer vary due to
           round off error

```

Scilab code Exa 2.16 a To Find the angles of Jet at Inlet and outlet of vane b To

```
1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.16
4     clc
5     clear
6
7 //Given Data:–
8     Vi=18;      //velocity of Jet at Inlet of, m/
9                 s
10    u=6;        //Velocity of Vane, m/s
11    ui=u;
12    uo=u;
13    AoD=110;    //Angle of deflection of the
14                Jet, degrees
15
16 //Data Used:–
17    g=9.81;    //Acceleration due to gravity, m/s
18                ^2
19
20 //Computations:–
21    beta_i=(180-AoD)/2;
22    beta_o=beta_i;
23
24 // (a)
25    alpha_i=beta_i-asind(ui*sind(180-beta_i)/Vi)
26                ; //degrees
27    Vwi=Vi*cosd(alpha_i); //m/s
28    Vfi=Vi*sind(alpha_i); //m/s
29    Vri=Vfi/sind(beta_i); //m/s
30    Vro=Vri;
31    Vfo=Vro*sind(beta_o); //m/s
32    Vrwo=Vro*cosd(beta_o); //m/s
```

```

29         Vwo=Vrwo-u0;           //m/s
30         alpha_o=atand(Vfo/Vwo); //degrees
31     //(b)
32         alpha_o_dash=180-alpha_o; //degrees
33     //(c)
34         W=(Vwi+Vwo)*u/g;       //N-m/N
35 //Results:-
36     printf("(a)Angle of Jet at Inlet of Vane,
37         alpha_i=%0.2f Degrees \n", alpha_i) //
38         The answer vary due to round off error
39     printf("    Angle at Outlet of Vane, alpha_o=%0
40         .2f Degrees \n", alpha_o) //The answer
41         vary due to round off error
42     printf("(b)Angle made by leaving Jet to the
43         direction of motion of Vane, alpha_o_dash=%0
44         .2f Degrees \n", alpha_o_dash) //The
45         answer vary due to round off error
46     printf("(c)Work done per second per unit weight
47         of water striking the vane per second=%0.2f
48         N-m/N", W) //The answer vary due to
49         round off error

```

Scilab code Exa 2.17 To Find a The force exerted by the Jet on the vane in the dir

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.17
4     clc
5     clear
6 //Given Data:-
7     d=60; //Diameter of Jet, mm
8     Vi=22; //Absolute Velocity of Jet at
9         Inlet, m/s
10    u=11; //Velocity of vane, m/s
11    ui=u;

```

```

11         uo=u;
12         alpha_i=0;    //degrees
13         alpha_l=65;   //degrees
14         alpha_o=180-alpha_l;    //degrees
15
16 //Data Used:-
17         rho=1000;    //Density of water , kg/m^3
18
19 //Computations:-
20
21         d=d/1000;    //m
22         a=(%pi/4)*d^2;    //cross-sectional area of
                Jet , m^2
23         Vwi=Vi;    //m/s
24         Vri=Vi-ui;    //m/s
25         Vro=Vri;
26         beta_o=alpha_o-asind(uo*sind(alpha_l)/Vro);
                //degrees
27         Vwo=uo-Vro*cosd(beta_o);    //m/s
28 // (a) The Force exerted by Jet on Vane in
                direction of motion , Fx
29         Fx=rho*a*Vri*(Vwi-Vwo);    //N
30 // (b) Power developed by vane ,
31         P=Fx*u/1000;    //kW
32 // (c) Efficiency of Vane ,
33         eta=2*Fx*u/(rho*a*Vi^3)*100;    //in
                Percentage
34
35 //Results:-
36         printf("(a)The Force exerted by Jet on Vane in
                direction of motion , Fx=%0.2f N \n", Fx)
                //The answer vary due to round off
                error
37         printf("(b)Power developed by vane=%0.3f kW \n"
                , P)    //The answer vary due to round off
                error
38         printf("(c)Efficiency of vane , eta=%0.2f percent
                \n", eta)    //The answer vary due to

```

round off error

Scilab code Exa 2.18 To Determine i The angle of Jet at Inlet of Vane ii The absol

```
1 //Fluid system - By - Shiv Kumar
2 //Chapter 2 - Impact of Jet
3 //Example 2.18
4     clc
5     clear
6
7 //Given Data:-
8     Vi=18;      //velocity of Jet at Inlet of, m/
9                 s
9     u=6;      //Velocity of Vane, m/s
10    ui=u;
11    uo=u;
12    AoD=120;   //Angle of deflection of the
13              Jet , degrees
14 //Data Used:-
15    g=9.81;    //Acceleration due to gravity ,
16              m/s^2
17 //Computations:-
18    beta_i=(180-AoD)/2;      //degrees
19    beta_o=beta_i;
20    //(i)
21    alpha_i=beta_i-asind(ui*sind(180-beta_i)/Vi)
22           ;                //degrees
23    //(ii)
24    Vrw=Vi*cosd(alpha_i)-ui; //m/s
25    Vfi=Vi*sind(alpha_i);    //m/s
26    Vri=Vfi/sind(beta_i);    //m/s
27    Vro=Vri;
28    Vfo=Vro*sind(beta_o);    //m/s
```

```

28         Vwo=Vro*cosd(beta_o)-uo;           //m/s
29         alpha_o=atand(Vfo/Vwo);           //degrees
30         Vo=Vfo/sind(alpha_o);           //m/s
31         //(iii)
32         W=(Vi*cosd(alpha_i)+Vwo)*u/g;     //N-m/N
33 //Results(a):-
34         printf("(i) Angle of Jet at Inlet , alpha_i=%0.2f
           Degrees \n", alpha_i)
35         printf("(ii) Absolute velocity of Jet at Outlet ,
           Vo=%0.2f m/s with angle alpha_o=%0.2f Degrees
           \n", Vo,alpha_o)           //The answer vary
           due to round off error
36         printf("(iii) Work done per N of Water=%0.2f N-m/
           N", W)           //The answer vary due to round
           off error

```

Scilab code Exa 2.19 To Find a Force exerted by the Jet on the plate in the direct

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.19
4     clc
5     clear
6
7 //Given Data:-
8     d=40;           //Diameter of the Jet , mm
9     V=24;           //Velocity of the Jet , m/s
10
11 //Data Used:-
12     rho=1000;      //Density of water , kg/m^3
13
14 //Computations:-
15     d=d/1000;      //m
16     a=(%pi/4)*d^2; //cross-sectional area
           of Jet , m^2

```



```

17 //CaseI – Jet strikes normal to a fixed plate
18 // (a)
19 Fx=rho*a*V^2; //N
20 // (b) Work done, W
21 W=0; //As there is no motion of flat
    plate
22 // (c)
23 eta=0; //Hydraulic efficiency is
    zero
24
25 //Result I:–
26 printf("Case I: \n\t")
27 printf("(a)Force exerted by Jet on the Plate in
    direction of Jet , Fx=%.2f N \n\t", Fx)
    //The answer vary due to round off
    error
28 printf("(b)Work done by Jet per second=%.2f N \
    n\t", W) //The answer vary due to round
    off error
29 printf("(c)Hydraulic efficiency of the Jet ,
    eta_H=%.2f percent \n\n", eta) //The
    answer vary due to round off error
30 //Case II – Jet strikes the moving plate
31 u=10; //Velocity of moving flat
    plate , m/s
32 // (a)
33 Fx=rho*a*(V-u)^2; //N
34 // (b)
35 W=Fx*u; //N–m/s
36 // (c)
37 eta=2*W/(rho*a*V^3)*100; //In
    percentage
38 //Result II
39 printf("Case II: \n\t")
40 printf("(a)Force exerted by Jet on the Plate in
    direction of Jet , Fx=%.2f N \n\t", Fx)
    //The answer vary due to round off
    error

```

```

41     printf("(b)Work done by Jet per second=%0.2 f N \
        n\t", W)          //The answer vary due to round
        off error
42     printf("(c)Hydraulic efficiency of the Jet ,
        eta_H=%0.2 f percent \n\n", eta)          //The
        answer vary due to round off error
43 //Case III – Jet strikes a series of flat moving
        plate
44     u=10;              //velocity of flat plate , m/
        s
45     //(a)
46     Fx=rho*a*V*(V-u);          //N
47     //((b)
48     W=Fx*u;                  //N-m/s
49     //(c)
50     eta=W*2/(rho*a*V^3)*100;          //In
        percentage
51 //Result III
52
53     printf("Case III: \n\t")
54     printf("(a)Force exerted by Jet on the Plate in
        direction of Jet , Fx=%0.3 f N \n\t", Fx)
        //The answer vary due to round off
        error
55     printf("(b)Work done by Jet per second=%0.2 f N \
        n\t", W)          //The answer vary due to round
        off error
56     printf("(c)Hydraulic efficiency of the Jet ,
        eta_H=%0.2 f percent \n\n", eta)          //The
        answer vary due to round off error

```

Scilab code Exa 2.20 To Find a Force exerted on a series of curved plate in direct

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet

```

```

3 //Example 2.20
4     clc
5     clear
6
7 //Given Data:-
8     d=40;           //Diameter of the Jet, mm
9     V=35;           //Absolute Velocity of the Jet, m/
10                    s
11    u=18;           //Velocity of the curved plate, m
12                    /s
13    AoD=165;        //Angle of deflection of
14                    the Jet, degrees
15
16 //Data Used:-
17    rho=1000;       //Density of water, kg/m^3
18
19 //Computations:-
20    d=d/1000;       //m
21    a=(%pi/4)*d^2;   //cross-sectional area
22                    of Jet, m^2
23    theta=180-AoD;   //degrees
24
25 //((a)
26    Fx=rho*a*V*(V-u)*(1+cosd(theta)); //N
27 //((b)Work done by Jet per second, W
28    W=Fx*u;         //N-m/s
29 //((c)
30    eta=W*2/(rho*a*V^3)*100; //In
31                    percentage
32
33 //Results:-
34    printf("(a)Force exerted on the series of
35            curved plates in direction of Jet, Fx=%0.2f N
36            \n", Fx) //The answer vary due to
37                    round off error
38    printf("(b)Work done by Jet per second=%0.2f N-m
39            /s \n", W) //The answer vary due to
40                    round off error

```

```

31     printf("(c) Efficiency of the Jet , eta=%0.2f
        percent", eta) //The answer vary due to
        round off error

```

Scilab code Exa 2.21 To Find a The work done per unit weight of water b Efficiency

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.21
4     clc
5     clear
6 //Given Data:–
7     Vi=30; //velocity of Jet at Inlet of, m/
        s
8     u=15; //Velocity of Vane, m/s
9     ui=u;
10    uo=u;
11    alpha_i=32; //Angle of Jet at Inlet ,
        degrees
12    alpha=125; //Angle made by Jet at
        Outlet with direction fo motion of Vanes,
        degrees
13    alpha_o=180-alpha; //degrees
14
15 //Data Used:–
16    g=9.81; //Acceleration due to gravity ,
        m/s^2
17    rho=1000; //Density of water , kg/m^3
18
19 //Computations:–
20    Vwi=Vi*cosd(alpha_i); //m/s
21    Vfi=Vi*sind(alpha_i); //m/s
22    Vrwi=Vwi-ui; //m/s
23    beta_i=atand(Vfi/Vrwi); //degrees
24    Vri=Vfi/sind(beta_i); //m/s

```

```

25     Vro=Vri;
26     beta_o=alpha_o-asind(uo*sind(180-alpha_o)/
        Vro);    //degrees
27
28     Vrwo=Vri*cosd(beta_o);    //m/s
29     Vwo=Vrwo-uo;    //m/s
30
31     //(a)
32     W=(Vwi+Vwo)*u/g;    //N-m/N (Answer in
        textbook is wrong due to wrong value of
        Vwi used)
33     //(b)Work done by Jet per second, W
34     eta=2*(Vwi+Vwo)*u/(Vi^2)*100;    //In
        percentage
35
36 //Results:-
37     printf("(a)Work done per unit weight of water=%
        .2f N-m/N \n", W)    //The answer
        provided in the textbook is wrong
38     printf("(b)Efficiency of the vane, eta=%0.2f
        percent", eta)    //The answer provided
        in the textbook is wrong

```

Scilab code Exa 2.22 To Determine a Vane Angles at entrance and exit b Work done o

```

1 //Fluid system - By - Shiv Kumar
2 //Chapter 2 - Impact of Jet
3 //Example 2.22
4     clc
5     clear
6 //Given Data:-
7     Vi=32;    //velocity of Jet at Inlet , m/s
8     u=16;    //Velocity of Vane, m/s

```

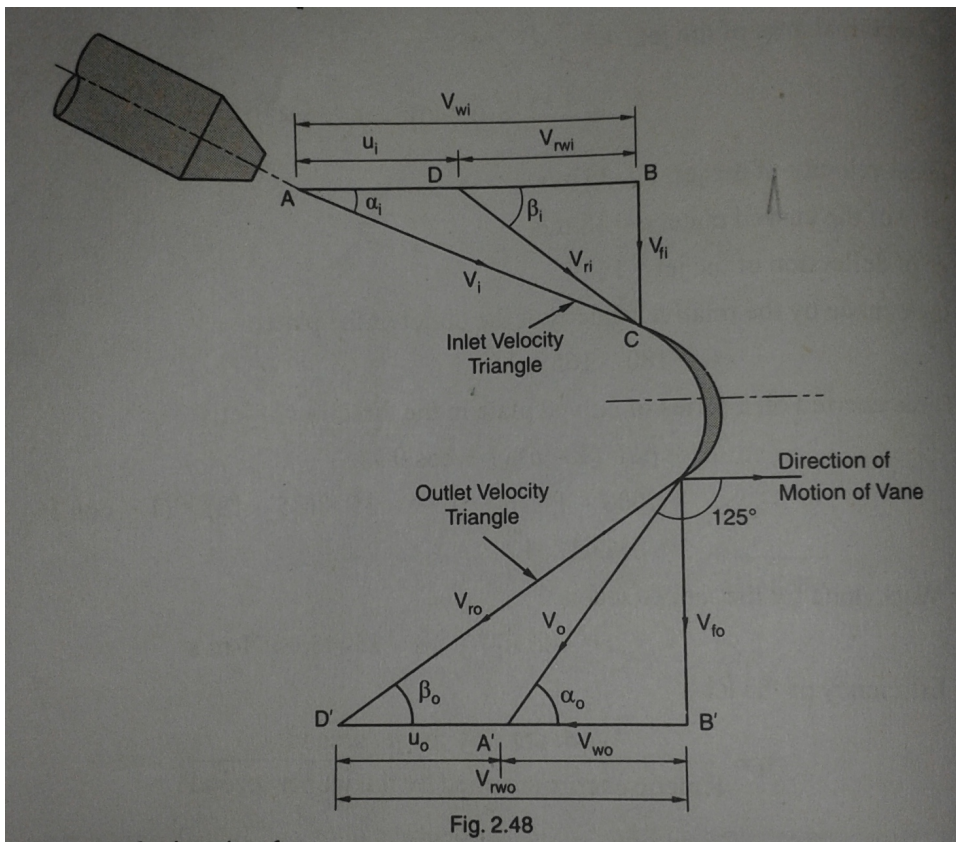


Figure 2.2: To Find a The work done per unit weight of water b Efficiency of the Vane

```

9         ui=u;
10        uo=u;
11        alpha_i=22;           //Angle of Jet at Inlet ,
                                degrees
12        K=0.92;              //Co-efficient of Vane
13
14 //Data Used:-
15        g=9.81;              //Acceleration due to gravity ,
                                m/s^2
16
17 //Computations:-
18        Vwi=Vi*cosd(alpha_i); //m/s
19        Vfi=Vi*sind(alpha_i); //m/s
20        Vrwi=Vwi-ui;         //m/s
21 // (a)
22        beta_i=atand(Vfi/Vrwi); //degrees
23        Vri=Vfi/sind(beta_i); //m/s
24        Vro=K*Vri;           //m/s
25        beta_o=acosd(uo/Vro); //degrees
26 // (b)
27        Vwo=0;                //m/s(as alpha_o=90 degrees)
28        W=(Vwi+Vwo)*u/g;      //N-m/N
29 // (c)
30        eta=2*Vwi*u/Vi^2*100; //In percentage
31
32 //Results:-
33        printf("(a)Vane angle at Entrance, beta_i=%0.2f
                                degrees \n", beta_i) //The answer vary
                                due to round off error
34        printf("    Vane angle at exit, beta_o=%0.2f
                                degrees \n", beta_o) //The answer vary
                                due to round off error
35        printf("(b)Work done on vanes per unit weight
                                of water=%0.2f N-m/N \n", W)
36        printf("(c)Efficiency of the system, eta=%0.2f
                                percent", eta) //The answer vary due to
                                round off error

```

Scilab code Exa 2.23 To Find a Speed of the wheel b Work done per unit weight of w

```
1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.23
4     clc
5     clear
6 //Given Data:–
7     Vi=65;      //Absolut velocity of Jet at
8                 Inlet , m/s
9     Ri=400;     //Inner radius of wheel, mm
10    Ro=800;     //outer radius of wheel, mm
11    alpha_i=24; //degrees
12    Vfo=12;     //Flow velocity at outlet , m/s
13    beta_i=40;  //blade angle at Inlet ,
14                degrees
15    beta_o=30;  //Blade angle at outlet ,
16                degrees
17
18 //Data Used:–
19    g=9.81;     //Acceleration due to gravity ,
20                m/s^2
21
22 //Computations:–
23    Ri=Ri/1000; //m
24    Di=2*Ri;    //m
25    Ro=Ro/1000; //m
26    Do=2*Ro;    //m
27    Vfi=Vi*sind(alpha_i); //m/s
28    Vwi=Vi*cosd(alpha_i); //m/s
29    Vrwi=Vfi/tand(beta_i); //m/s
30
31 // (a)
32    ui=Vwi-Vrwi; //m/s
33    N=ui*60/(%pi*Do); //rpm
```



```

29         omega=2*%pi*N/60;           //rad/s
30         uo=%pi*Di*N/60;             //m/s
31         Vro=Vfo/sind(beta_o);       //m/s
32         Vrwo=Vro*cosd(beta_o);      //m/s
33         Vwo=Vrwo-uo;                //m/s
34     //(b)
35         W=(Vwi*ui+Vwo*uo)/g;        //Work done per
           unit weight of water, N-m/N
36     //(c)
37         eta=(Vwi*ui+Vwo*uo)*2/Vi^2*100; //In
           percentage
38
39 //Results:-
40     printf("(a)For the speed of wheel: \n\t")
41     printf("N=%0.2f rpm \n\t", N) //The answer
           vary due to round off error
42     printf("Angular velocity , omega=%0.2f rad/s \n\t")
           //The answer vary due to
           round off error
43     printf("Peripheral velocity of wheel at outlet ,
           uo=%0.2f m/s \n\t", uo)
44     printf("Vwo=%0.2f m/s \n\n", Vwo) //The
           answer vary due to round off error
45     printf("(b)Work done per unit weight of water=%0.2f N-m/N \n", W) //The answer vary
           due to round off error
46     printf("(c)Efficiency of the system , eta=%0.2f
           percent", eta) //The answer vary due to
           round off error

```

Scilab code Exa 2.24 To Find a Blade angles at entry and exit b Velocity of water

```

1 //Fluid system - By - Shiv Kumar
2 //Chapter 2 - Impact of Jet
3 //Example 2.24

```

```

4      clc
5      clear
6
7      //Given Data:-
8          Do=1.5;          //Diameter of rotor at inlet of
                          vane , m
9          Di=1;          //Diameter of rotor at outlet of
                          vane , m
10         N=400;          //Speed of the rotor , rpm
11         Vi=15;          //m/s
12         alpha_i=12;     //Nozzle angle at inlet ,
                          degrees
13         Vo=5;          //m/s
14         Vfo=Vo;
15      //Data Used:-
16         g=9.81;        //Acceleration due to gravity ,
                          m/s^2
17
18      //Computations:-
19         ui=%pi*Do*N/60;          //m/s
20         uo=%pi*Di*N/60;          //m/s
21         Vfi=Vi*sind(alpha_i);    //m/s
22         Vfo=Vo;                  //m/s
23         Vwi=Vi*cosd(alpha_i);    //m/s
24      //(a)
25         Vrw=ui-Vwi;              //m/s
26         beta_i=180-atand(Vfi/Vrw); //Blade
                          angle at inlet , degrees
27         beta_o=atand(Vfo/uo);    //Blade angle
                          at outlet , degrees
28      //(b)
29         vro=uo/cosd(beta_o);     //m/s
30      //(c)
31         W=Vwi*ui/g;             //N-m/N
32
33      //Results:-
34         printf("(a) Blade angle at entry and exit are:
                          \n\t")

```

```

35     printf("beta_i=%0.2f degrees \t beta_o=%0.2f
           degrees \n\n", beta_i,beta_o)      //The
           answer vary due to round off error
36     printf("(b) Velocity of water relative to Vanes
           at exit , Vro=%0.2f m/s \n", Vro)  //The
           answer vary due to round off error
37     printf("(c) Work done per second per unit weight
           of water strikes on Vane per second=%0.2f N-
           m/N", W)      //The answer vary due to round
           off error

```

Scilab code Exa 2.25 To Find a Vane angles at inlet and outlet b Work done per sec

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.25
4     clc
5     clear
6
7 //Given Data:-
8     Vi=32;      //Absolute velocity of Jet at
           inlet , m/s
9     N=250;     //Speed of the wheel, rpm
10    alpha_i=20; //angle of Jet at inlet ,
           degrees
11    Vo=6;      //Absolute velocity of Jet at
           outlet , m/s
12    alpha=132; //Angle made by Jet at
           outlet with tangent to wheel, degrees
13    alpha_o=180-alpha; //degrees
14    Do=1.2;    //outer Diameter of wheel, m
15    Di=0.75;   //Inner diameter of wheel, m
16
17 //Data Used:-
18    g=9.81;    //Acceleration due to gravity,

```

```

19         m/s^2
20 // Computations:-
21         ui=%pi*Do*N/60;           //m/s
22         uo=%pi*Di*N/60;           //m/s
23         //(a)
24         Vfi=Vi*sind(alpha_i);     //m/s
25         Vwi=Vi*cosd(alpha_i);     //m/s
26         Vrwi=Vwi-ui;              //m/s
27         Vwo=Vo*cosd(alpha_o);     //m/s
28         Vrwo=uo+Vwo;              //m/s
29         Vfo=Vo*sind(alpha_o);     //m/s
30         beta_i=atand(Vfi/Vrwi);    //degrees
31         beta_o=atand(Vfo/Vrwo);    //degrees
32         //(b)
33         W=(Vwi*ui+Vwo*uo)/g;      //N-m/N
34         //(c)
35         eta=2*(Vwi*ui+Vwo*uo)/Vi^2*100; //in
           percentage
36
37 // Results:-
38         printf("(a)Vane angle at Inlet , beta_i=%0.2f
           degrees \n", beta_i) //The answer vary
           due to round off error
39         printf("    Vane angle at Outlet , beta_o=%0.2f
           degrees \n", beta_o) //The answer vary
           due to round off error
40         printf("(b)Work done per second per unit weight
           of water strikes on vane per second=%0.2f N-
           m/N \n", W) //The answer vary due to
           round off error
41         printf("(c)Efficiency of the wheel , eta=%0.2f
           percent",eta) //The answer vary due to
           round off error

```

Scilab code Exa 2.26 To Find the force exerted by the Jet of water on the statione

```
1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.26
4     clc
5     clear
6
7 //Given Data:–
8     H=4;           //Head of water in tank, m
9     d=150;        //Diameter of orifice, mm
10    Cv=0.96;
11
12 //Data Used:–
13    rho=1000;      //Density of water, kg/m^3
14    g=9.81;       //Acceleration due to gravity,
15                  m/s^2
16
17 //Computations:–
18    d=d/1000;     //m
19    a=(%pi/4)*d^2; //cross-sectional are
20                  of orifice, m^2
21    V=Cv*sqrt(2*g*H); //Velocity of Jet,
22                  m/s
23    F=rho*a*V^2;  //Force exerted on
24                  tank, N
25
26 //Results:–
27    printf("The force exerted on the tank=%0.2f n",
28           F) //The answer vary due to round off
29           error
```

Scilab code Exa 2.27 To Find a Propelling force on the tank b Work done by the pro

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.27
4     clc
5     clear
6
7 //Given Data:–
8     H=3.8;           //Head of water in tank, m
9     d=200;          //Diameter of orifice, mm
10    Cv=0.97;
11    u=2;             //Velocity of tank, m/s
12
13 //Data Used:–
14    rho=1000;        //Density of water, kg/m^3
15    g=9.81;         //Acceleration due to gravity,
16                      m/s^2
17
18 //Computations:–
19    d=d/1000;        //m
20    a=(%pi/4)*d^2;   //cross-sectional area
21                      of orifice, m^2
22    V=Cv*sqrt(2*g*H); //Velocity of Jet,
23                      m/s
24
25 // (a)
26    F=rho*a*(V+u)*V; //N
27
28 // (b)
29    W=F*u;           //N–m/s
30
31 // (c)
32    eta=2*V*u/(V+u)^2*100; //in
33                      Percentage
34
35 //Results:–
36
37 printf("(a) Propelling Force on tank, F=%0.2f N \
38        \n", F) //The answer provided in the
39                textbook is wrong
40
41 printf("(b) Work done by propelling force per
42        second=%0.2f N–m/s \n", W) //The
43        answer provided in the textbook is wrong

```

```

31     printf("(c) Efficiency of propulsion , eta=%0.2f
        percent", eta) //The answer vary due to
        round off error

```

Scilab code Exa 2.28 To Determine a Propelling force on the boat b Power required

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.28
4     clc
5     clear
6
7 //Given Data:–
8     V=20; //Absolute Velocity of Jet of
        Water, m/s
9     a=0.02; //Cross-sectional area of Jet,
        m^2
10    u=30; //Speed of boat , km/hr
11
12 //Data Used:–
13    rho=1000; //Density of water , kg/m^3
14
15 //Computations:–
16    u=u*1000/3600; //m/s
17    //(a)
18    Fx=rho*a*(V+u)*V; //N
19    //(b)
20    P=Fx*u/1000; //kW
21    //(c)
22    eta=2*V*u/(V+u)^2*100; //in
        Percentage
23
24 //Results:–
25    printf("(a) Propelling Force on the boat , Fx=%0.f
        N \n", Fx) //The answer vary due to

```

```

        round off error
26     printf("(b)power required to drive the pump=%.2
        f kW \n", P) //The answer vary due to
        round off error
27     printf("(c)Efficiency of the Jet propulsion ,
        eta=%.2f percent", eta) //The answer
        vary due to round off error

```

Scilab code Exa 2.29 To Find a Propelling force on the boat b Power required to dr

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.29
4     clc
5     clear
6
7 //Given Data:–
8     V=20; //Absolute Velocity of Jet of
        Water, m/s
9     a=0.18; //Cross-sectional area of Jet,
        m^2
10    u=30; //Speed of boat, km/hr
11
12 //Data Used:–
13    rho=1000; //Density of water, kg/m^3
14
15 //Computations:–
16    u=u*1000/3600; //m/s
17    //(a)
18    Fx=rho*a*(V+u)*V/1000; //kN
19    //(b)
20    P=Fx*u; //kW
21    //(c)
22    eta=2*V*u/(V+u)^2*100; //in
        Percentage

```



```

23
24 //Results:-
25     printf("(a) Propelling Force on the boat, Fx=%0.4
        f kN \n", Fx)
26     printf("(b) power required to drive the pump=%0.2
        f kW \n", P)
27     printf("(c) Efficiency of the Jet propulsion,
        eta=%0.2 f percent", eta)

```

Scilab code Exa 2.30 To Find the propelling Force and Efficiency of propulsion

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.30
4     clc
5     clear
6
7 //Given Data:-
8     V=40;           //Absolute Velocity of Jet, m/s
9     a=0.04;        //Cross-sectional area of Jet,
                    m^2
10    u=40;           //Speed of boat, km/hr
11
12 //Data Used:-
13    rho=1000;       //Density of water, kg/m^3
14
15 //Computations:-
16    u=u*1000/3600; //m/s
17    F=rho*a*(V+u)*V; //N
18    eta=2*u/(V+2*u)*100; //in
                    Percentage
19
20 //Results:-
21    printf("(a) Propelling Force, F=%0.f N \n", F)
        //The answer vary due to round off error

```

```

22     printf("(b) Efficiency of propulsion , eta=%0.2f
        percent" , eta)

```

Scilab code Exa 2.31 To Find i The volume of water drawn by the pump per second ii

```

1 //Fluid system - By - Shiv Kumar
2 //Chapter 2 - Impact of Jet
3 //Example 2.31
4 //To Find (i)The volume of water drawn by the pump
    per second (ii)The Efficiency of Jet propulsion.
5     clc
6     clear
7
8 //Given Data:-
9     F=5890; //Total resistance offered to
        motion , N
10    a=424; //Total area of Jet , cm^2
11    u=6; //Speed of boat , m/s
12
13 //Data Used:-
14    rho=1000; //Density of water , kg/m^3
15
16 //Computaions:-
17    a=a/10000; //m^2
18 //For solving Quadratic in V
19    A=rho*a;
20    B=rho*a*u;
21    C=-F;
22    V=(-B+sqrt(B^2-4*C*A))/(2*A); //m/
        s
23 // (i)
24    Q=a*(V+u); //m^3/s
25 // (ii)
26    eta=2*V*u/(V+u)^2*100; //In
        percentage

```

```

27
28 //Results:-
29     printf("(i)The Volume of water drawn by the
        pump per second=%0.4f m^3/s \n", Q) //
        The answer vary due to round off error
30     printf("(ii)The Efficiency of Jet propulsion ,
        eta=%0.2f percent", eta) //The answer
        vary due to round off error

```

Scilab code Exa 2.32 To Find the propelling Force and Efficiency of Propulsion

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.32
4     clc
5     clear
6
7 //Given Data:-
8     V=18; //Absolute Velocity of the Jet, m
        /s
9     a=0.04; //cross-sectional area of Jet,
        m^2
10    u=28; //Speed of the ship, km/hr
11
12 //Data Used:-
13    rho=1000; //Density of water, kg/m^3
14
15 //Computations:-
16    u=u*1000/3600; //m/s
17    //(a)
18    F=rho*V*a*(V+u); //N
19    //(b)
20    eta=2*u/(V+2*u)*100; //In percentage
21
22 //Results:-

```

```

23     printf("(a) Propelling Force, F=%0.1f N \n", F)
24     printf("(b) The Efficiency of propulsion, eta=%0
      .2f percent \n", eta) //The answer
      vary due to round off error

```

Scilab code Exa 2.33 To Find a Propelling Force and b Overall Efficiency

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 2 – Impact of Jet
3 //Example 2.33
4     clc
5     clear
6
7 //Given Data:–
8     a=0.72; //Total cross-sectional
      area of Jets, m^2
9     Vr=12; //Velocity through the Jet
      relative to ship, m/s
10    u=6; //Speed of ship, m/s
11    eta_E=85/100; //Efficiency of I.C.
      engine
12    eta_P=70/100; //Efficiency of
      Centrifugal Pump
13    Pipe_Loss_per=8; //Percentage of pipe
      losses (of the kinetic energy of Jet per
      sec)
14
15 //Data Used:–
16    rho=1000; //Density of water, kg/m^3
17
18 //Computations:–
19    Pipe_Loss=(Pipe_Loss_per/100)*(rho*a*Vr^3/2)
      ; //Pipe Losses, N-m/s
20    V=Vr-u; //Absolute Velocity of the
      Jet, m/s

```

```

21     //(a)
22     F=rho*V*a*(V+u);           //N
23     //(b)
24     W=F*u;                     //Work done by Jet per second ,
                                N-m/s
25     OE_P=rho*a*Vr^3/2+Pipe_Loss; //
                                Output energy of pump per sec , N-m/s
26     IP_P=OE_P/eta_P;           //Input Energy
                                of pump per sec , N-m/s
27     OE_E=IP_P;                 //Output of Engine is
                                equal to Input to the pump
28     IE_E=OE_E/eta_E;           //Input Energy of
                                Engine per sec , N-m/s
29     eta_o=W/IE_E*100;          //Overall
                                Efficiency in percentage
30
31 //Results:-
32     printf("(a) Propelling Force=%f N \n", F)
33     printf("(b) Overall Efficiency , eta_o=%f
                                percent", eta_o) //The answer vary due
                                to round off error

```

Scilab code Exa 2.34 To Find a The volume of water drawn by the pump per second b

```

1 //Fluid system - By - Shiv Kumar
2 //Chapter 2 - Impact of Jet
3 //Example 2.34
4     clc
5     clear
6
7 //Given Data:-
8     F=100800; //Total resistance offered to
                motion , N
9     a=0.8; //Total area of Jet , m^2
10    u=5; //Speed of boat , m/s

```

```

11
12 //Data Used:-
13     rho=1000;           //Density of water , kg/m^3
14
15 //Computations:-
16     //For solving Quadratic in V
17     A=rho*a;
18     B=rho*a*u;
19     C=-F;
20     V=(-B+sqrt(B^2-4*C*A))/(2*A);           //m/
21     s
22     // (a)
23     Q=a*(V+u);           //m^3/s
24     // (b)
25     eta=2*V*u/(V+u)^2*100;           //In
26     percentage
27
28 //Results:-
29     printf("(a)The Volume of water drawn by the
30     pump per second=%0.1f m^3/s \n", Q)
31     printf("(b)The Efficiency of Jet propulsion ,
32     eta=%0.2f percent", eta)           //The answer
33     vary due to round off error

```

Scilab code Exa 2.35 i To Find a Resistance to the motion of ship b Propulsion wor

```

1 //Fluid system - By - Shiv Kumar
2 //Chapter 2 - Impact of Jet
3 //Example 2.35
4     clc
5     clear
6
7 //Given Data:-
8     Vr=14;           //Relative Velocity of ship , m/s
9     a=0.025;           //cross-sectional area of Jet

```

```

    , m^2
10     u=32;           //Speed of ship , km/hr
11     eta_P=80/100;  //Efficiency of pump
12     h_f=2.5;       //Frictional Losses , m of
    water
13
14 //Data Used:-
15     rho=1000;      //Density of water , kg/m^3
16     g=9.81;       //Acceleration due to
    gravity , m/s^2
17
18 //Computations:-
19     u=u*1000/3600; //m/s
20 // (i)
21 // (a)
22     V=Vr-u;       //m/s
23     F=rho*V*a*(V+u); //N
24 // (b)
25     W=F*u;        //N-m/s, Value in textbook
    is wrong due to incorrect value of u ia
    used.
26 // (ii)
27     E=rho*a*Vr*((Vr^2-u^2)/2+g*h_f);
    //Actual energy supplied to
    water per second , N-m/s
28     OE_P=E;       //Output fluid energy per
    second of pump
29 // (a)
30     P=OE_P/eta_P; //Power required to
    drive the pump, W
31 // (b)
32     eta_o=W/P*100; //In percentage
33
34 //Results:-
35     printf("(i) (a) Resistance to the motion of ship
    , F=%f N \n", F) //The answer
    provided in the textbook is wrong
36     printf(" (b) Propulsive work per second=%f.2 f

```

```

    N-m/s \n\n", W)           //The answer
    provided in the textbook is wrong
37 printf("(ii) (a)Power required to drive the
    pump=%0.2f W \n", P)       //The answer
    provided in the textbook is wrong
38 printf("      (b)Overall Efficiency of
    propulsion, eta_o=%0.2f percent", eta_o)
    //The answer vary due to round off
    error

```

Chapter 4

Pelton Turbine Impulse Turbine

Scilab code Exa 4.1 To Determine a Diameter of turbine b The number of Jets requir

```
1 //Fluid system – By – Shiv Kumar
2 //Chapter 4 – Pelton Turbine (Impulse Turbine)
3 //Example 4.1
4     clc
5     clear
6
7 //Given Data:–
8     P=735.75;           //Power Developed , kW
9     H=200;             //Head , m
10    N=800;             //Speed , rpm
11    eta_0=86/100;      //Overall Efficiency
12    d_by_D=1/10;       //Ratio of Jet diameter to
                        turbine diameter (d/D)
13    Cv=0.98;           //Co-efficient of velocity
14    Ku=0.45;           //Speed ratio
15
16 //Data Used:–
17    rho=1000;          //Density of water , kg/m^3
18    g=9.81;           //Acceleration due to gravity , m
```

```

18         /s^2
19
20 // Computations:-
21     Q=P*1000/(rho*g*H*eta_0);           //Net
22         discharge , m^3/s
23 // (a) Diameter of Turbine , D
24     D=60*Ku*sqrt(2*g*H)/(%pi*N);       //m
25     d=D*d_by_D;                         //m
26 // (b) The no. of Jets required
27     q=(%pi/4)*d^2*Cv*sqrt(2*g*H);      //
28         Discharge of a single Jet , m^3/s
29     n=round(Q/q);                       //No. of Jets
30 // (c) Diameter of Jet , d
31     d=d_by_D*D;                         //m
32
33 // Results:-
34     printf("(a) Diameter of Turbine , D=%0.4 f m \n",
35         D) //The answer vary due to round off
36         error
37     printf("(b) The number of Jets required , n=%0. f
38         \n", n)
39     printf("(c) Diameter of Jet , d=%0.4 f m \n", d)

```

Scilab code Exa 4.2 To Find a The power given by water to runner and b The hydraul

```

1 // Fluid system – By – Shiv Kumar
2 // Chapter 4 – Pelton Turbine (Impulse Turbine)
3 // Example 4.2
4     clc
5     clear
6
7 // Given Data:-
8     u=12; // Speed of bucket , m/s
9     ui=u;
10    uo=u;

```

```

11         Q=650;           //Discharge , liters/s
12         H=40;           //Head of water , m
13         AoD=162;       //Angle of Deflection ,
           degrees
14         Cv=0.98;       //Co-efficient of Velocity
15
16 //Data Used:-
17         rho=1000;      //Density of water , kg/m^3
18         g=9.81;       //Acceleration due to gravity , m
           /s^2
19
20 //Computations:-
21         Q=Q/1000;      //m^3/s
22         beta_0=180-AoD; //Blade angle a
           outlet , degrees
23         Vi=Cv*sqrt(2*g*H); //Velocity of
           Jet , m/s
24         Vwi=Vi;
25         Vri=Vi-ui;     //m/s
26         Vro=Vri;
27         Vrwo=Vro*cosd(beta_0); //m/s
28         Vwo=Vrwo-uo;   //m/s
29 // (a) Power given by water to runner , P
30         P=rho*Q*(Vwi+Vwo)*u/1000; //kW
31 // (b) The hydraulic efficiency , eta_H
32         eta_H=2*(Vwi+Vwo)*u/Vi^2*100; //In
           percentage
33
34 //Results:-
35         printf("(a)The Power given by water to the
           runner=%0.3f kW \n", P) //The answer
           vary due to round off error
36         printf("(b)The Hydraulic Efficiency of Turbine ,
           eta_H=%0.2f percent \n", eta_H) //The
           answer vary due to round off error

```

Scilab code Exa 4.3 To Find a The power given by water to runner b Hydraulic effie

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 4 – Pelton Turbine (Impulse Turbine)
3 //Example 4.3
4     clc
5     clear
6
7 //Given Data:–
8     H=30;           //Effective Head, m
9     AoD=165;       //Jet Deflection Angle,
10                    degrees
11     Cv=0.98;       //Co-efficient of Velocity
12     Ku=0.45;       //Speed ratio
13     d=22;          //Diameter of Jet, mm
14 //As relative velocity at outlet is 0.98 times
15 //relative velocity at inlet,
16     Vro_by_Vri=0.98; // Vro/Vri
17
18 //Data Used:–
19     rho=1000;      //Density of water, kg/m^3
20     g=9.81;        //Acceleration due to gravity, m
21                    /s^2
22
23 //Computations:–
24     d=d/1000;      //m
25     beta_0=180-AoD; //degrees
26     Vi=Cv*sqrt(2*g*H); //Absolut
27                    Velocity of Jet, m/s
28     Vwi=Vi;
29     u=Ku*sqrt(2*g*H); //peripheral
30                    velocity of runner, m/s
31     ui=u;
32     uo=u;

```

```

28     Vri=Vi-ui;           //m/s
29     Vro=Vro_by_Vri*Vri; //m/s
30     Vrho=Vro*cosd(beta_0); //m/s
31     Vwo=Vrho-uo;       //m/s
32
33     //(a)Power given by water to runner , P
34     Q=(%pi/4)*d^2*Vi;   //m^3/s
35     P=rho*Q*(Vwi+Vwo)*u/1000; //kW
36
37     //(b)The hydraulic efficiency , eta_H
38     eta_H=2*(Vwi+Vwo)*u/Vi^2*100; //In
           percentage
39
40 //Results:-
41     printf("(a)The Power given by water to the
           runner=%0.3f kW \n", P) //The answer
           vary due to round off error
42     printf("(b)The Hydraulic Efficiency , eta_H=%0.2f
           percent \n", eta_H) //The answer vary
           due to round off error

```

Scilab code Exa 4.4 To Determine the specific speed of the Turbine

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 4 – Pelton Turbine (Impulse Turbine)
3 //Example 4.4
4     clc
5     clear
6
7 //Given Data:-
8     Cv=0.97;
9     Ku=0.46;
10    K=0.98;
11    m=10.2;
12    beta_o=10; //Bucket angle at exit ,

```

```

degrees
13     eta_m=90.5/100;           //Mechanical
      Efficiency
14
15 //Data Used:-
16     rho=1000;           //Density of water , kg/m^3
17     g=9.81;           //Acceleration due to gravity , m
      /s^2
18
19 //Computations:-
20     Vi_by_rootH=Cv*sqrt(2*g);           //Vi/sqrt(H)
      )
21     Vwi_by_rootH=Vi_by_rootH;
22     ui_by_rootH=Ku*sqrt(2*g);           //ui/sqrt
      (H)
23     Vri_by_rootH=Vi_by_rootH-ui_by_rootH;
      //Vi/sqrt(H)
24     Vro_by_rootH=K*Vri_by_rootH;           //Vro/
      sqrt(H)
25     Vrwo_by_rootH=Vro_by_rootH*cosd(beta_o);
      //Vrwo/sqrt(H)
26     Vwo_by_rootH=Vrwo_by_rootH-ui_by_rootH;
      //Vwo/sqrt(H)
27     Q_by_d2_rootH=(%pi/4)*Vi_by_rootH;           //
      Q/(d^2*sqrt(H))
28 //Pr=Power developed by runner
29     Pr_by_d2_H3_2=rho*Q_by_d2_rootH*(
      Vwi_by_rootH+Vwo_by_rootH)*ui_by_rootH;
      //Pr/(d^2*H^(3/2)), P in W
30 //P=Shaft Power
31     P_by_d2_H3_2=eta_m*Pr_by_d2_H3_2/1000;
      //P/(d^2*H^(3/2)), P in kW
32     N_d_by_rootH=ui_by_rootH*60/(%pi*m);
      //N*d/sqrt(h), N in rpm
33     Ns=N_d_by_rootH*sqrt(P_by_d2_H3_2);
      //Specific Speed in SI Units
34
35 //Results:-

```

```

36     printf("The Specific Speed of the Turbine , Ns=%  

    .f (SI Units)", Ns)

```

Scilab code Exa 4.5 To Find the Overall Efficiency of the Turbine

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 4 – Pelton Turbine (Impulse Turbine)
3 //Example 4.5
4     clc
5     clear
6
7 //Given Data:–
8     n=2;           //Number of Jets
9     P=15450;       //Shaft Power, kW
10    d=200;          //Diameter of each Jet , mm
11    H=400;          //Net Head, m
12    Cv=1;
13
14 //Data Used:–
15    rho=1000;       //Density of water , kg/m^3
16    g=9.81;         //Acceleration due to gravity , m
    /s^2
17
18 //Computations:–
19    P=P*1000;       //W
20    d=d/1000;       //m
21    Vi=Cv*sqrt(2*g*H); //Absolute
    Velocity of Jet at Inlet , m/s
22    q=(%pi/4)*d^2*Vi; //Discharge
    through each Jet , m^3/s
23    Q=n*q;          //Net Discharge
24    eta_0=P/(rho*Q*g*H)*100; //Overall
    Efficiency , in percentage
25
26 //Results:–

```

```

27     printf("The Overall Efficiency of the Turbine ,
           eta_o=%0.2f percent", eta_0)           //The
           answer vary due to round off error

```

Scilab code Exa 4.6 To Find i Resultant force on the bucket ii Shaft Power iii Over

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 4 – Pelton Turbine (Impulse Turbine)
3 //Example 4.6
4     clc
5     clear
6 //Given Data:–
7     N=300;           //Speed of runner , rpm
8     H=510;          //Head, m
9     d=200;          //Diameter of the Jet , mm
10    AoD=165;         //Angle of Jet(Deflection
                       inside bucket), degrees
11    Vel_per=15;      //Percentage by which
                       velocity is reduced due to friction
12    Loss_per=3;      //Percentage of
                       mechanical Losses (of power Supplied)
13
14 //Data Used:–
15    rho=1000;        //Density of water , kg/m^3
16    g=9.81;         //Acceleration due to gravity , m
                       /s^2
17    Cv=0.98;        //Co-efficient of Velocity
18    Ku=0.46;        //Speed ratio
19
20 //Computations:–
21    d=d/1000;        //m
22    beta_0=180-AoD; //degrees
23    Vro_by_Vri=1-Vel_per/100; //Vro/Vri
24    Vi=Cv*sqrt(2*g*H); //m/s
25    Vwi=Vi;

```



```

26     u=Ku*sqrt(2*g*H);           //m/s
27     uo=u;
28     ui=u;
29     Vri=Vi-ui;                 //m/s
30     Vro=Vri*Vro_by_Vri;       //m/s
31     Vrho=Vro*cosd(beta_0);     //m/s
32     Vwo=uo-Vrho;              //m/s
33     Q=(%pi/4)*d^2*Vi;         //Discharge , m
                                   ^3/s
34 // (i) Resultant Force on bucket , F
35     F=rho*Q*(Vwi-Vwo)/1000;    //kN
36
37 //Result (i):-
38     printf("(i) Resultant Force on bucket , F=%0.3f
39     kN \n", F) //The answer vary due to
40     round off error
41
42 // (ii) Shaft Power , P
43     Pr=F*u;                    //power developed by
44     runner , kW
45     P=Pr-(Loss_per/100)*Pr;    //kW
46
47 //Result (ii)
48     printf("(ii) Shaft Power , P=%0.3f kW \n", P)
49     //The answer given in the textbook is
50     wrong (due to round off error in F)
51 //OR
52     eta_m=1-Loss_per/100;      //Mechanical
53     Efficiency
54     P=eta_m*Pr;                //kW
55
56 // (iii) Overall Efficiency , eta_O
57     eta_O=P*1000/(rho*Q*g*H)*100; //In
58     percentage
59 //Result (iii)
60     printf("(iii) Overall efficiency , eta_O=%0.2f
61     percent", eta_O)

```

Scilab code Exa 4.7 To Determine the power given by the water to the runner and Hy

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 4 – Pelton Turbine (Impulse Turbine)
3 //Example 4.7
4     clc
5     clear
6
7 //Given Data:–
8     H_G=500;           //Gross Head, m
9     h_f=(1/3)*H_G;    //Head lost in
                        friction in penstock, m
10    Q=2;               //Discharge, m^3/s
11    AoD=165;          //Angle of Deflection of
                        Jet, degrees
12    Ku=0.45;          //Speed ratio
13    Cv=1;
14
15 //Data Used:–
16    rho=1000;         //Density of water, kg/m^3
17    g=9.81;           //Acceleration due to gravity, m
                        /s^2
18
19 //Computations:–
20    H=H_G-h_f;        //Working Head, m
21    Vi=Cv*sqrt(2*g*H); //m/s
22    Vwi=Vi;
23    u=Ku*sqrt(2*g*H); //m/s
24    ui=u;
25    uo=u;
26    Vri=Vi-u;        //m/s
27    Vro=Vri;
28    beta_o=180-AoD;  //degrees
29    Vrwo=Vro*cosd(beta_o); //m/s

```

```

30     Vwo=Vrwo-u0;           //m/s
31     P=rho*Q*(Vwi+Vwo)*u/1000; //power
        given by water to runner, kW
32     eta_H=2*(Vwi+Vwo)*u/Vi^2*100; //
        Hydraulic efficiency, In percentage
33
34 //Results:-
35     printf("Power given by water to the runner=%0.2f
        kW \n", P) //The answer vary due
        to round off error
36     printf("Hydraulic efficiency, eta_H=%0.2f
        percent", eta_H) //The answer vary due
        to round off error

```

Scilab code Exa 4.8 To Determine the Flow Rate and Shaft Power developed by the Turbine

```

1 //Fluid system - By - Shiv Kumar
2 //Chapter 4 - Pelton Turbine (Impulse Turbine)
3 //Example 4.8
4     clc
5     clear
6
7 //Given Data:-
8     Cv=0.97; //Co-efficient of Velocity
9     H_l=400; //Head at lake, m
10    d=80; //Diameter of Jet, mm
11    D_pipe=0.6; //Diameter of pipe, m
12    l=4; //Length of pipe, m
13    f_dash=0.032; //Friction factor
14    AoD=165; //Angle of Deflection,
        degrees
15    beta_o=180-AoD; //degrees
16 // As bucket runs at 0.48 Jet speed
17    u_by_Vi=0.48; //u/Vi
18    Vel_per=15; //percentage by which

```

```

                velocity is reduced
19         eta_m=90/100;           //Mechanical Efficiency
20
21 //Data Used:-
22         rho=1000;           //Density of water , kg/m^3
23         g=9.81;           //Acceleration due to gravity , m
                /s^2
24
25 //Computations:-
26         d=d/1000;           //m
27         l=l*1000;           //m
28         Vro_by_Vri=1-Vel_per/100;           //Vro/Vri
29 //using continuity equation ,
30         V_by_Vi=(d/D_pipe)^2;           //V/Vi
31         Vi=sqrt((2*g*H_l)/(1/Cv^2+f_dash*l*V_by_Vi
                ^2/D_pipe));           //m/s
32         Vwi=Vi;
33         u=Vi*u_by_Vi;           //m/s
34         ui=u;
35         uo=u;
36         Vri=Vi-ui;           //m/s
37         Vro=Vri*Vro_by_Vri;           //m/s
38         Vrwo=Vro*cosd(beta_o);           //m/s
39 // (i) Flow Rate , Q
40         Q=(%pi/4)*d^2*Vi;           //m^3/s
41 // (ii) Shaft Power , P
42         Vwo=uo-Vrwo;           //m/s
43         Pr=rho*Q*(Vwi-Vwo)*u/1000;           //Power
                developed by the runner , kW
44         P=eta_m*Pr;           //kW
45
46 //Results:-
47         printf("Flow Rate, Q=%0.4f m^3/s \n", Q)
                //The answer vary due to round off error
48         printf("Shaft power, P=%0.2f kW", P)           //The
                answer vary due to round off error

```

Scilab code Exa 4.9 To Find i Diameter of the Turbine and ii Diameter of the Jet

```

1 //Fluid system – By – Shiv Kumar
2 //Chapter 4 – Pelton Turbine (Impulse Turbine)
3 //Example 4.9
4     clc
5     clear
6
7 //Given Data:–
8     P=3000;           //Power developed , kW
9     H=300;           //Head, m
10    N=375;           //Speed , rpm
11    eta_0=83/100;     //Overall efficiency
12    Ku=0.46;         //Speed ratio
13    Cv=0.98;         //Co-efficient of Velocity
14
15 //Data Used:–
16    rho=1000;        //Density of water , kg/m^3
17    g=9.81;         //Acceleration due to gravity , m
18                    //s^2
19 //Computations:–
20 // (i) Diameter of Turbine , D
21    D=60*Ku*sqrt(2*g*H)/(%pi*N);           //m
22 // (ii) Diameter of Jet , d
23    Q=P*1000/(rho*g*H*eta_0);             //m^3/s
24    Vi=Cv*sqrt(2*g*H);                   //m/s
25    d=(Q/((%pi/4)*Vi))^(1/2);           //m
26
27 //Results:–
28    printf("(i) Diameter of the Turbine , D=%0.2f m
29           \n", D)           //The answer vary due to round
                               off error
    printf("(ii) Diameter of the Jet , d=%0.4f m", d)

```

```
        //The answer vary due to round off
error
```

Scilab code Exa 4.10 To Determine i Water power available at the inlet of turbine

```
1 //Fluid system - By - Shiv Kumar
2 //Chapter 4 - Pelton Turbine (Impulse Turbine)
3 //Example 4.10
4     clc
5     clear
6
7 //Given Data:-
8     N=300;           //Speed of runner , rpm
9     H=510;           //Head, m
10    d=200;           //Diameter of the Jet , mm
11    AoD=165;        //Angle of Deflection ,
                        degrees
12    Vel_per=15;      //percentage by which
                        velocity is reduced
13
14 //Data Used:-
15    rho=1000;        //Density of water , kg/m^3
16    g=9.81;         //Acceleration due to gravity , m
                        /s^2
17    Cv=0.98;
18    Ku=0.46;
19
20 //Computations:-
21    d=d/1000;        //m
22    beta_0=180-AoD; //degrees
23    Vro_by_Vri=1-Vel_per/100; //Vro/Vri
24    Vi=Cv*sqrt(2*g*H); //m/s
25    Vwi=Vi;
26    ui=Ku*sqrt(2*g*H); //m/s
27    uo=ui;
```

```

28     u=ui;
29     Vri=Vi-ui;           //m/s
30     Vro=Vri*Vro_by_Vri; //m/s
31     Vrwo=Vro*cosd(beta_0); //m/s
32     Vwo=uo-Vrwo;       //m/s
33
34     //(i) Water power available at inlet of turbine , P
35     Q=(%pi/4)*d^2*Vi;   //m^3.s
36     P=(1/2)*rho*Q*Vi^2/1000; //kW
37     //(ii) Resultant force on the bucket , F
38     F=rho*Q*(Vwi-Vwo)/1000; //kN
39     //(iii) Overall Efficiency , eta_o
40     eta_H=F*u/P;       //Hydraulic
41     efficiency
42     //Assume ,
43     eta_V=100/100;     //Volumetric efficiency
44     is 100%
45     eta_m=98/100      //Mechanical Efficiency
46     is 98%
47
48     eta_0=eta_V*eta_H*eta_m*100; //In
49     percentage
50
51 //Results:-
52 printf("(i)Water power available at inlet of
53 turbine=%0.2f kW \n", P) //The answer
54 provided in the Textbook is wrong
55 printf("(ii) Resultant force on the bucket , F=%0
56 .3f kN \n", F) //The answer vary due to
57 round off error
58 printf("(iii) Overall efficiency , eta_O=%0.2f
59 percent", eta_0) //The answer vary due
60 to round off error

```

Scilab code Exa 4.11 To Find a Water power b The Force on the bucket in the direct

```

1 //Fluid system - By - Shiv Kumar
2 //Chapter 4 - Pelton Turbine (Impulse Turbine)
3 //Example 4.11
4
5     clc
6     clear
7
8 //Given Data:-
9         N=300;           //Speed of runner , rpm
10        H=500;           //Head, m
11        d=200;           //Diameter of the Jet , mm
12        AoD=165;        //Angle of Deflection ,
                            degrees
13        Vel_per=15;      //percentage by which
                            velocity is reduced
14        Cv=0.98;        //Co-efficient of Velocity
15        Ku=0.46;        //Speed ratio
16        Loss_per=3;     //Percentage of Mechanical
                            losses
17
18 //Data Used:-
19        rho=1000;       //Density of water , kg/m^3
20        g=9.81;        //Acceleration due to gravity , m
                            /s^2
21
22
23 //Computations:-
24        d=d/1000;       //m
25        beta_0=180-AoD; //degrees
26        Vro_by_Vri=1-Vel_per/100; //Vro/Vri
27        K=Vro_by_Vri;
28        Vi=Cv*sqrt(2*g*H); //m/s
29        Vwi=Vi;
30        ui=Ku*sqrt(2*g*H); //m/s
31        uo=ui;
32        u=ui;
33        Vri=Vi-ui;      //m/s
34        Vro=K*Vri;     //m/s

```



```

35     Vrwo=Vro*cosd(beta_0);           //m/s
36     Vwo=u0-Vrwo;                    //m/s
37
38     //(a) Water power , WP
39     Q=(%pi/4)*d^2*Vi;                //m^3.s
40     WP=rho*Q*g*H/1000;              //kW
41
42     //(b)The Force on the bucket in the direction of
43     Jet , F
44     F=rho*Q*(Vwi-Vwo)/1000;         //kN
45
46     //(c) Shaft Power , SP
47     Pr=F*u;                          //Power developed by the Runner , W
48     SP=Pr-Loss_per/100*Pr;          //kW
49
50     //(d) Overall Efficiency , eta_o
51     eta_o=SP/WP*100;                 //In percentage
52
53     //Results:-
54     printf("(a) Water power , WP=%0.2f kW \n",WP)
55     //The answer provided in the Textbook is
56     wrong
57     printf("(b)The Force on the bucket in the
58     direction of Jet=%0.3f kN \n", F) //The
59     answer vary due to round off error
60     printf("(c) Shaft Power , SP=%0.3f kW\n",SP) //
61     The answer provided in the Textbook is wrong
62     printf("(d) Overall efficiency , eta_o=%0.2f
63     percent", eta_o) //The answer vary due
64     to round off error

```

Scilab code Exa 4.12 To Find a Efficiency of the Runner b The Diameter of each Jet

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 4 – Pelton Turbine (Impulse Turbine)

```

```

3 //Example 4.12
4
5     clc
6     clear
7
8 //Given Data:-
9     n=2;           //Number of Jets
10    P=5000;        //Shaft Power, HP
11    N=375;         //Speed of Shaft, rpm
12    Hth=200;       //Theoretical Head at Base of
                    //Nozzle, m
13    eta_p=90/100;  //Efficiency of Power
                    //Transmission
14    D=1.65;        //Diameter of the Runner, m
15    Vel_per=10;    //Percentage by which
                    //velocity is decreased
16    Deflection=165; //Jet Deflection,
                    //degrees
17    eta_o=90/100;  //Overall Efficiency
18    Cv=0.98;
19
20
21 //Data Used:-
22    rho=1000;      //Density of water, kg/m
                    //^3
23    g=9.81;        //Acceleration due to
                    //gravity, m/s^2
24
25 //Computations:-
26    P=P*736;       //W
27    Hact=eta_p*Hth; //Actual Head
                    //available at base of Nozzle, m
28    Vro_by_Vri=1-Vel_per/100; //Vro/
                    //Vri
29    beta_o=180-Deflection; //degrees
30
31    u=%pi*D*N/60;  //Velocity of
                    //Runner, m/s

```

```

32         ui=u;
33         uo=u;
34         Vi=Cv*sqrt(2*g*Hact);           //m/s
35         Vwi=Vi;
36         Vri=Vi-u;           //m/s
37         Vro=Vri*Vro_by_Vri;           //m/s
38         Vrwo=Vro*cosd(beta_o);           //m/s
39         Vwo=uo-Vrwo;           //m/s
40
41         //(a) Efficiency of Runner, eta_H
42         eta_H=2*(Vwi-Vwo)*u/Vi^2*100;
43         //In Percentage
44
45         //(b) Diameter of each jet , d
46         Q=P/(rho*g*Hact*eta_o);           //
47         //Discharge , m^3/s
48         d=sqrt(Q/((%pi/4)*n*Vi));           //Diameter
49         //of each Jet , m
50
51 //Results:-
52 printf("(a) Efficiency of the Runner, eta_H=%0.2
53 f Percent\n",eta_H)           //The answer vary
54 due to round off error
55 printf("(b) Diameter of each Jet , d=%0.3 f m\n",
56 d)

```

Scilab code Exa 4.13 To Find a Diameter of the Jet b Diameter of the Runner c Width

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 4 – Pelton Turbine (Impulse Turbine)
3 //Example 4.13
4
5     clc
6     clear
7

```

```

8 //Given Data:-
9     H=62;           //Effective Head, m
10    N=225;          //Speed of Runner, rpm
11    P=133.15;       //Shaft Power, HP
12    Ku=0.45;        //Speed Ratio
13    eta_o=86/100;   //Overall Efficiency
14    Cv=0.98;
15
16
17 //Data Used:-
18    rho=1000;       //Density of water, kg/m
19                    ^3
20    g=9.81;         //Acceleration due to
21                    gravity, m/s^2
22
23 //Computations:-
24    P=P*736;        //W
25
26    Vi=Cv*sqrt(2*g*H); //m/s
27    u=Ku*sqrt(2*g*H); //m/s
28    ui=u;
29    uo=u;
30    Q=P/(rho*g*H*eta_o); //m^3/s
31
32    d=sqrt(Q/((%pi/4)*Vi))*1000; //
33    Diameter of Jet, mm
34    D=60*u/(%pi*N); //Diameter of
35    Runner, m
36    //As per designing range, b=3*d to 4*d
37    b=3.5*d; //Width of Buckets, mm
38    //As per designing range, b=0.8*d to 1.2*d
39    T=1.2*d; //Depth of Buckets, mm
40    Z=round(0.5*D/(d/1000)+15); //Number
41    of Buckets
42
43 //Results:-
44    printf(" (a)Diameter of Jet, d=%f mm \n",
45           d) //The answer vary due to round

```

```

    off error
40 printf(" (b) Diameter of Runner, D=%0.3 f m \
    n",D)
41 printf(" (c) Width of Buckets, b=%0.2 f mm \n
    ",b) //The answer vary due to
    round off error
42 printf(" (d) Depth of Buckets, T=%0.2 f mm \n
    ",T) //The answer vary due to
    round off error
43 printf(" (e) Number of Buckets , Z=%0.f \n"
    ,Z)

```

Scilab code Exa 4.14 To Find a Diameter of the Jet b Diameter of the Runner c Power

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 4 – Pelton Turbine (Impulse Turbine)
3 //Example 4.14
4
5     clc
6     clear
7
8 //Given Data:-
9     H=452; //Net Head, m
10    m=12; //Jet Ratio (D/d)
11    Ku=0.46; //Speed Ratio
12    AoD=165; //Angle of Jet Deflection ,
    degrees
13    Cv=0.98; //Co-efficient of Velocity
14    Loss_f=15; //Percentage of Friction Loss
    of Buckets
15    eta_o=86/100; //Overall Efficiency
16    P_G=10200; //Power developed by
    Generator, HP
17    eta_G=95/100; //Generator Efficiency
18

```

```

19
20 //Data Used:-
21     rho=1000;           //Density of water , kg/m
                ^3
22     g=9.81;           //Acceleration due to
                gravity , m/s^2
23
24 //Computations:-
25     P_G=P_G*736;       //W
26     Vro_by_Vri=1-Loss_f/100;           //Vro/
                Vri
27     beta_o=180-AoD;   //degrees
28
29     u=Ku*sqrt(2*g*H); //Velocity of
                Runner , m/s
30     ui=u;
31     uo=u;
32     Vi=Cv*sqrt(2*g*H); //m/s
33     Vwi=Vi;
34     Vri=Vi-ui;       //m/s
35     Vro=Vri*Vro_by_Vri; //m/s
36     Vrwo=Vro*cosd(beta_o); //m/s
37     Vwo=uo-Vrwo;    //m/s
38
39     P=P_G/eta_G;     //Shaft Power , W
40     Q=P/(rho*g*H*eta_o); //Discharge ,
                m^3/s
41
42 // (a)
43     d=sqrt(Q/((%pi/4)*Vi)); //Diameter of
                Jet , m
44
45 // (b)
46     D=m*d;          //Diameter of Runner , m
47
48 // (c)
49     Pr=rho*Q*(Vwi-Vwo)*u/1000; // Power
                developed by Runner , kW

```

```

50
51     //(d)
52     eta_m=P/(Pr*1000)*100;           //Mechanical
           Efficiency in Percentage
53
54
55 //Results:-
56     printf("(a) Diameter of the Jet , d=%0.3 f m\n",d
           )
57     printf(" (b)Diameter of the Runner , D=%0.3 f m\n
           ",D)           //The answer vary due to round
           off error
58     printf(" (c)Power Developed by the Runner=%0.3 f
           kW\n",Pr)           //The answer provided in
           the textbook is wrong
59     printf(" (d)Mechanical Efficiency , eta_m=%0.2 f
           Percent\n",eta_m)           //The answer vary
           due to round off error

```

Scilab code Exa 4.15 To Find a Power lost in Nozzle b Power lost due to Hydraulic

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 4 – Pelton Turbine (Impulse Turbine)
3 //Example 4.15
4
5     clc
6     clear
7
8 //Given Data:-
9     H=120;           //Head, m
10    d=74;           //Diameter of Jet , mm
11    Q=200;           //Discharge , litres/s
12    P=202.766;       //Shaft Power, kW
13    P_mr=3.2;       //Power lost in mechanical
           resistance , kW

```

```

14
15
16 //Data Used:-
17     rho=1000;           //Density of water , kg/m
18     ^3
19     g=9.81;           //Acceleration due to
20     gravity , m/s^2
21
22 //Computations:-
23     Q=Q/1000;           //m^3/s
24     d=d/1000;           //m
25     P=P*1000;           //W
26     P_mr=P_mr*1000;     //W
27
28     Vi=Q/((%pi/4)*d^2); //m/s
29     P_n=(rho*Q*g*H-rho*Q*Vi^2/2)/1000;
30     //Power lost in Nozzle , kW
31     P_hr=(rho*Q*g*H-(P+P_n*1000+P_mr))/1000;
32     //Power lost due to hydraulic
33     resistance in Runner, kW
34
35 //Results:-
36     printf(" (a) Power lost in Nozzle=%0.3f kW\n",P_n
37     ) //The answer vary due to round off
38     error
39     printf(" (b)Power lost due to Hydraulic
40     Resistance in Runner =%0.2f kW\n",P_hr)
41     //The answer vary due to round off
42     error

```

Scilab code Exa 4.16 To Find a The Power available at the base of Nozzle b Overall

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 4 – Pelton Turbine (Impulse Turbine)

```



```

3 //Example 4.16
4
5     clc
6     clear
7
8 //Given Data:-
9     P=4900;           //Shaft Power, kW
10    P_mr=100;        //Power absorbed in mechanical
        resistance , kW
11    eta_H=92/100;    //Hydraulic Efficiency
12    P_n=415;        //Power lost in Nozzle, kW
13
14
15 //Computations:-
16    P_rd=P+P_mr;     //Power Devloped by
        Runner, kW
17    P_rs=P_rd/eta_H; //Power Supplied to
        Runner, kW
18    P_an=P_n+P_rs;   //Power Available at
        base of Nozzle, kW
19    eta_o=P/P_an*100; //Overall
        Efficiency in Percentage
20
21 //Results:-
22    printf("(a)Power Available at the Base of
        Nozzle=%0.3f kW\n",P_an) //The
        answer vary due to round off error
23    printf("(b)Overall Efficiency , eta_o=%0.2f
        Percent\n",eta_o)

```

Scilab code Exa 4.17 To Find a Power developed by the runner b Hydraulic efficiency

```

1 //Fluid system - By - Shiv Kumar
2 //Chapter 4 - Pelton Turbine (Impulse Turbine)
3 //Example 4.17

```

```

4
5     clc
6     clear
7
8 //Given Data:-
9     H_G=510;           //Gross Head, m
10    h_f=(1/3)*H_G;     //Head lost in
        friction in penstock, m
11    d=170;           //Diameter of Jet, mm
12    AoD=165;        //Angle of Deflection of
        Jet, degrees
13    Ku=0.45;        //Speed ratio
14    Cv=0.98;        //Co-efficient of Velocity
15
16 //Data Used:-
17    rho=1000;       //Density of water, kg/m^3
18    g=9.81;        //Acceleration due to gravity, m
        /s^2
19
20 //Computations:-
21    H=H_G-h_f;      //Effective Head, m
22    Vi=Cv*sqrt(2*g*H); //m/s
23    Vwi=Vi;
24    u=Ku*sqrt(2*g*H); //m/s
25    ui=u;
26    uo=u;
27    Vri=Vi-u;      //m/s
28    Vro=Vri;
29    beta_o=180-AoD; //degrees
30    Vrwo=Vro*cosd(beta_o); //m/s
31    Vwo=Vrwo-uo;   //m/s
32    Q=(%pi/4)*(d/1000)^2*Vi; //Discharge,
        m^3/s
33    P=rho*Q*(Vwi+Vwo)*u/1000; //Power
        developed by runner, kW
34    eta_H=2*(Vwi+Vwo)*u/Vi^2*100; //
        Hydraulic efficiency, In percentage
35

```

```

36 //Results:-
37     printf("(a)Power developed by the runner=%0.3f
        kW \n",P) //The answer provided in the
        Textbook is wrong
38     printf("(b)Hydraulic efficiency , eta_H=%0.2f
        percent", eta_H) //The answer vary
        due to round off error

```

Scilab code Exa 4.18 To Find a Speed of runner in rpm b Diameter of each Jets c Me

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 4 – Pelton Turbine (Impulse Turbine)
3 //Example 4.18
4
5     clc
6     clear
7
8 //Given Data:-
9     Ns=15; //Specific Speed
10    P=1200; //Shaft Power, kW
11    Ht=500; //Total Head at reservoir, m
12    Loss_per=5; //Percentage of Head loss in
        Pipe friction
13    Cv=0.98; //Co-efficient of Velocity
14    Ku=0.45; //Speed Ratio
15    eta_o=85/100; //Overall Efficiency
16    n=2; //Number of Jets
17
18 //Data Used:-
19    rho=1000; //Density of water, kg/m
        ^3
20    g=9.81; //Acceleration due to
        gravity, m/s^2
21
22 //Computations:-

```

```

23         H=Ht-Loss_per/100*Ht;           // Effective
           Head, m
24
25     //(a)Speed of Runner, N
26         N=Ns*H^(5/4)/sqrt(P/n);       //rpm
27
28     //(b)Diameter od each Jet, d
29         Q=P*1000/(rho*g*H*eta_o);     //Net
           Discharge, m^3/s
30         q=Q/n;                         //Net Discharge per
           Jet, m^3/s
31         Vi=Cv*sqrt(2*g*H);           //m/s
32         d=sqrt(q/((%pi/4)*Vi));      //m
33
34     //(c)Mean Diameter of Bucket Circle, D
35         D=Ku*60*sqrt(2*g*H)/(%pi*N); //m
36
37     //(d)Number of Buckets in the Runner, Z
38         Z=round(0.5*D/d+15);
39
40 // Results:-
41     printf(" (a)Speed of the Runner, N=%f rpm\
           n",N)
42     printf(" (b)Diameter od each Jet, d =%.3 f m
           \n",d)
43     printf(" (c)Mean Diameter of Bucket Circle,
           D =%.3 f m\n",D)
44     printf(" (d)Number of Buckets on the Runner
           , Z =%.f \n",Z)

```

Scilab code Exa 4.19 To Find a Shaft Power b Diameter of the Jet c Diameter of the

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 4 – Pelton Turbine (Impulse Turbine)
3 //Example 4.19

```

```

4
5     clc
6     clear
7
8 //Given Data:-
9     Q=2.5;           //Total Discharge , m3/s
10    Hr=300;         //Head from reservoir to base
11                    // of nozzle , m
12    n=6;           //Total number of Jets
13    L=1200;        //Lenght of Pipe , m
14    eta_p=92/100;   //Efficiency of Power
15                    // Transmission
16    eta_o=86/100;   //Overall Efficiency
17    Cv=0.97;       //Co-efficient of Velocity
18    f=0.0025;      //Darcy Co-efficient of
19                    // Friction
20
21 //Data Used:-
22    rho=1000;      //Density of water , kg/m
23                    // ^3
24    g=9.81;       //Acceleration due to
25                    // gravity , m/s2
26
27 //Computations:-
28    h_f=(1-eta_p)*Hr; //m
29    H=Hr-h_f;        // Effective Head , m
30    Vi=Cv*sqrt(2*g*H); //Velocity
31                    // of Jet , m/s
32
33 // (a) Shaft Power , P
34    P=rho*Q*g*H*eta_o/1000; //kW
35
36 // (b) Diameter of the Jet , d
37    q=Q/n;          // Discharge per Jet , m3/s
38    d=sqrt(q/((%pi/4)*Vi)); //m
39
40 // (c) Diameter of the Pipe , D_pipe

```

```

36         D_pipe=(64*f*L*Q^2/(h_f*2*g*pi^2))^(1/5)
           *1000;           //mm
37
38 // Results:-
39     printf(" (a) Shaft Power , P=%0.3 f kW\n" ,P)
40     printf(" (b) Diameter of the Jet , d=%0.4 f m\n"
           ,d)
41     printf(" (c) Diameter of the Pipe , D_pipe=%0.2
           f mm\n" ,D_pipe)           //The answer vary
           due to round off error

```

Scilab code Exa 4.20 To Find a Diameter of the the Nozzle b Speed Ratio c Specific

```

1 // Fluid Systems – By – Shiv Kumar
2 // Chapter 4 – Pelton Turbine (Impulse Turbine)
3 // Example 4.20
4
5     clc
6     clear
7
8 // Given Data:-
9     D=1.6;           //Mean Diameter of Bucket Circle
           , m
10    P=3200;           //Power Developed , kW
11    n=2;           //Number of Wheels
12    H=300;           //Effective Head, m
13    N=410;           //Speed , rpm
14    eta_o=0.89;           //Overall Efficiency
15    Cv=0.98;           //Co-efficient of Velocity
16
17
18 // Data Used:-
19    rho=1000;           //Density of water , kg/m
           ^3
20    g=9.81;           //Acceleration due to

```

```

21         gravity , m/s^2
22 //Computations:-
23     Q=P*1000/(rho*g*H*eta_o);           //
24     Discharge , m^3/s
25     //(a)Diameter of the Nozzle , d
26     Vi=Cv*sqrt(2*g*H);                 //m/s
27     d=sqrt(Q/((%pi/4)*Vi))*1000;
28     //mm
29     //(b)Speed Ratio , Ku
30     u=%pi*D*N/60;                       //m/s
31     Ku=u/sqrt(2*g*H);
32
33     //(c)Specific Speed , Ns
34     Ns=N*sqrt(P/n)/(H^(5/4));           // In SI
35     Units
36
37 //Results:-
38     printf(" (a)Diameter of the Nozzle , d=%0.2f mm
39     \n",d) //The answer vary due to
40     round off error
41     printf(" (b)Speed Ratio , Ku =%0.3f \n",Ku)
42     //The answer vary due to round off
43     error
44     printf(" (c)Specific Speed , Ns =%0.f (SI Units
45     )\n",Ns)

```

Chapter 5

Francis Turbine

Scilab code Exa 5.1 To Find a Discharge passing through the Runner and b Width of

```
1 //Fluid Systems– By Shiv Kumar
2 //Chapter 5– Francis Turbine
3 //Example 5.1
4 //To Find (a) Discharge passing through the Runner
   and (b) Width of Runner at Outlet
5
6     clc
7     clear
8
9 //Given Data:–
10    Do=0.8;           //External Diameter of the Runner
   , m
11    Di=0.4;           //Internal Diameter of the
   Runner, m
12    Vfi=1.4;          //Velocity of Flow at Inlet , m/s
13    Vfo=Vfi;          //Velocity of Flow at Outlet , m/s
14    bo=210;           //Width of Runner at Inlet , mm
15
16 //Computations:–
17    Q=%pi*Do*(bo/1000)*Vfi;           //Discharge
   passing through the Runner, m^3/s
```



```

18         bi=Do*bo/Di;           //Width of Runner at
           Outlet , mm
19
20 //Results
21 printf("(a) Discharge passing through the Runner, Q
           =%.4f m^3/s\n",Q)      //The Answer Vary due
           to Round off Error
22 printf("(b) Width of Runner at Outlet , bi=%.f mm",
           bi)

```

Scilab code Exa 5.2 To Find a Discharge b Power Developed and c Hydraulic Efficiency

```

1 //Fluid Systems– By Shiv Kumar
2 //Chapter 5– Francis Turbine
3 //Example 5.2
4 //To Find (a) Discharge (b) Power Developed and
   (c) Hydraulic Efficiency
5
6     clc
7     clear
8
9 //Given Data:–
10    Do=1.2;           //Diameter of Runner at Inlet , m
11    Ao=0.4;           //Area of Flow at Inlet , m^2
12    N=500;            //Speed of Runner, rpm
13    H=135;            //Head, m
14    alpha_i=20;       //Guide Vane Angle at Inlet ,
           degrees
15    beta_i=65;        //Vane angle at Inlet ,
           degrees
16
17 //Data Required:–
18    rho=1000;         //Density of Water, Kg/m^3
19    g=9.81;           //Acceleration due to
           gravity , m/s^2

```

```

20
21
22 // Computations:-
23     ui=%pi*Do*N/60;           //m/s
24     Vri=ui*sind(alpha_i)/sind(beta_i-alpha_i);
25                               //m/s
26     Vfi=Vri*sind(beta_i);    //m/s
27     Vwi=Vfi/tand(alpha_i);   //m/s
28
29 // (a) Discharge , Q
30     Q=Ao*Vfi;                //m^3/s
31
32 // (b) Power developed by Runner
33     P=rho*Q*Vwi*ui/1000;     //kW
34
35 // (c) Hydraulic Efficiency , eta_H
36     eta_H=Vwi*ui*100/(g*H);  //
37                               Percentage
38
39 // Results:-
40 printf(" (a) Discharge , Q=%0.3f m^3/s\n ",Q) //The
41                               Answer Vary due to Round off Error
42 printf(" (b) Power developed by Runner=%0.3f kW\n ",P)
43                               //The Answer provided in the Textbook is
44                               Wrong
45 printf(" (c) Hydraulic Efficiency , eta_H =%0.2f
46 Percent\n ",eta_H)           //The Answer Vary due
47                               to Round off Error

```

Scilab code Exa 5.3 To Find a The Absolute Velocity of Water at Inlet of Runner b

```

1 // Fluid Systems– By Shiv Kumar
2 // Chapter 5– Francis Turbine

```

```

3 //Example 5.3
4 //To Find (a)The Absolute Velocity of Water at
      Inlet of Runner (b)The Velocity of Whirl at
      Inlet (c) The Relative Velocity at Inlet
5 // (d) The Runner Blade Angles (e)Width of
      Runner at Outlet (f)Weight of Water
      flowing through the Runner per second
6 // (g)Head at Inlet of the Turbine (h)Power
      developed (i) Hydraulic Efficiency of
      the Turbine

7
8     clc
9     clear
10
11 //Given Data:-
12     Do=1; // External Diameter of Runner ,
           m
13     Di=0.5; //Internal Diameter of Runner , m
14     N=200; //Speed of Turbine , rpm
15     bo=225; //Width of Runner at Inlet , mm
16
17
18     Vfi=2.15; //Velocity of flow at Inlet , m/s
19 // As Velocity of Flow is constant through the
      Runner ,
20     Vfo=Vfi; //Velocity of flow at Outlet , m/
           s
21     Vo=Vfo;
22     alpha_i=11; //Guide Blades Angle at
           Inlet , degrees
23 //As Discharge at Outlet of the Turbine is Radial
           ,
24     alpha_o=90; //Guide Blades angle at
           Outlet , degrees
25     Vwo=0;
26
27
28 //Data Required:-

```

```

29     rho=1000;           //Density of Water, Kg/m^3
30     g=9.81;           //Acceleration due to
                        gravity , m/s^2
31
32
33 // Computations:-
34     ui=%pi*Do*N/60;    //m/s
35
36 // (a)The Absolute Velocity of Water at Inlet of
      Runner ,
37     Vi=Vfi/sind(alpha_i); //m/s
38
39 // (b)The Velocity of Whirl at Inlet ,
40     Vwi=Vfi/tand(alpha_i); //m/s
41
42
43 // (c) The Relative Velocity at Inlet ,
44     Vri=sqrt(Vfi^2+(Vwi-ui)^2); //m/
      s
45
46 // (d) The Runner Blade Angles, beta_i, beta_o
47     beta_i=asind(Vfi/Vri); //Runner
      Blade Angle at Inlet , degrees
48     uo=%pi*Di*N/60; //m/s
49     beta_o=atand(Vfo/uo); //Runner
      Blade Angle at Outlet , degrees
50
51 // (e)Width of Runner at Outlet , bi
52     bi=Do*bo/Di; //mm
53
54 // (f)Weight of Water flowing through the Runner
      per second , W
55     W=rho*g*%pi*Do*(bo/1000)*Vfi/1000;
      //kN/s
56
57 // (g)Head at Inlet of the Turbine , H
58     H=Vwi*ui/g+Vo^2/(2*g); //m
59

```

```

60 // (h)Power developed by the Runner ,
61     Q=%pi*Do*(bo/1000)*Vfi;           //m^3/s
62     P=rho*Q*Vwi*ui/1000;           //kW
63 // (i)Hydraulic Efficiency , eta_H
64     eta_H=Vwi*ui*100/(g*H);         //In
        Percentage
65
66 //Results:-
67     printf(" (a)The Absolute Velocity of Water at
        Inlet of Runner , Vi=%0.3 f m/s\n",Vi)
        //The Answer Vary due to Round off Error
68     printf(" (b)The Velocity of Whirl at Inlet ,
        Vwi=%0.2 f m/s\n",Vwi)
69     printf(" (c) The Relative Velocity at Inlet ,
        Vri=%0.2 f m/s\n",Vri)
70     printf(" (d) The Runner Blade Angles are:- \n
        beta_i =%0.2 f Degrees and beta_o
        =%0.2 f Degrees\n",beta_i,beta_o) //
        The Answer Vary due to Round off Error
71     printf(" (e)Width of Runner at Outlet , bi =%0.
        f mm\n",bi)
72     printf(" (f)Weight of Water flowing through
        the Runner per second , W =%0.2 f kN/s\n",W)
        //The Answer Vary due to Round off
        Error
73     printf(" (g)Head at Inlet of the Turbine , H =%0
        .3 f m\n",H) //The Answer Vary due to
        Round off Error
74     printf(" (h)Power developed by the Runner =%0.3
        f kW\n",P) //The Answer Vary due to
        Round off Error
75     printf(" (i)Hydraulic Efficiency , eta_H =%0.2 f
        Percent\n",eta_H) //The Answer Vary
        due to Round off Error

```

Scilab code Exa 5.4 To Find a Diameter and Width at Inlet ant Outlet b Runner Vane

```

1 //Fluid Systems– By Shiv Kumar
2 //Chapter 5– Francis Turbine
3 //Example 5.4
4 //To Find (a)Diameter and Width at Inlet ant Outlet
      (b)Runner Vane Angles at Inlet and Outlet (
      c)Guide Blade Angles
5
6     clc
7     clear
8
9 //Given Data:–
10     H=70;           //Net Head, m
11     N=700;         //Speed , rpm
12     P=330;         //Shaft Power , kW
13     eta_o=85/100;   //Overall Efficiency
14     eta_H=92/100;   //Hydraulic Efficiency
15     Kf=0.22;       //Flow Ratio
16     bo_by_Do=0.1;   //Breadth Ratio
17     t_per=6;       //Percentage of
      Circumferential Area occupied by the
      Thickness of Vanes
18     Kt=1-t_per/100; //Vane Thickness
      Factor
19     //As Outer Diameter= 2 times the Inner
      Diameter ,
20     Do_by_Di=2;     //Do/Di
21
22
23 //Data Required:–
24     rho=1000;       //Density of Water , Kg/m^3
25     g=9.81;        //Acceleration due to gravity , m/
      s^2
26
27 //Computations:–
28     Vfi=Kf*sqrt(2*g*H); //m/s
29     Vfo=Vfi;

```

```

30         Q=P*1000/(rho*g*H*eta_o);           //m^3/s
31
32         //(a)Diameter and Width at Inlet ant Outlet ,
           Do,bo, Di and bi.
33         Do=sqrt(Q/(Kt*%pi*bo_by_Do*Vfi));
           //m
34         Di=Do/Do_by_Di;                       //m
35         bo=Do*bo_by_Do*1000;                 //mm
36         bi=Do*bo/Di;                          //mm
37
38         ui=%pi*Do*N/60;                       //m/s
39         uo=%pi*Di*N/60;                       //m/s
40         Vwi=eta_H*g*H/ui;                     //m/s
41
42         //(b)Runner Vane Angles at Inlet and Outlet ,
           beta_i ,beta_o
43         beta_i=atand(Vfi/(Vwi-ui));           //
           Runner Vane Angle at Inlet ,
           degrees
44         beta_o=atand(Vfo/uo);                 //Runner
           Vane Angle at Outlet , degrees
45
46         //(c)Guide Vane Angle , alpha_i
47         alpha_i=atand(Vfi/Vwi);              //
           degrees
48         //As flow is radial at outlet ,
49         alpha_o=90;                           //degrees
50
51 //Results:-
52 printf(" (a)Diameter and Width at Inlet and
           Outlet are: \n\t")
53 printf("Do=%0.3 f m      bo=%0.1 f mm\n      Di=
           %0.3 f m      bi=%0.1 f mm\n",Do,bo,Di,bi)
           //The Answer Vary due to Round off
           Error
54 printf(" (b)Runner Vane Angles at Inlet and
           Outlet are:- \n      beta_i=%0.2 f Degrees ,
           beta_o =%0.2 f Degrees \n",beta_i,beta_o)

```

```

//The Answer Vary due to Round off
Error
55 printf(" (c)Guide Vane Angles, \n      alpha_i=%g
      .2f Degrees , alpha_o=%g.f Degrees\n ",
      alpha_i, alpha_o) //The Answer Vary due
      to Round off Error

```

Scilab code Exa 5.5 To Determine a Guide Blade Angle b Runner Vane Angles at Inlet

```

1 //Fluid Systems– By Shiv Kumar
2 //Chapter 5– Francis Turbine
3 //Example 5.5
4 //To Determine (a) Guide Blade Angle (b)Runner
  Vane Angles at Inlet and Outlet (c) Diameter
  of Runner at Inlet and Outlet (d) Width of
  Wheel at Inlet.
5
6 clc
7 clear
8
9 //Given Data:–
10 H=70; //Net Head, m
11 N=600; //Speed, rpm
12 P=367.875; //Shaft Power, kW
13 eta_o=85/100; //Overall Efficiency
14 eta_H=95/100; //Hydraulic Efficiency
15 Kf=0.25; //Flow Ratio
16 bo_by_Do=0.1; //Breadth Ratio
17 t_per=10; //Percentage of
  Circumferential Area occupied by the
  Thickness of Vanes
18 Kt=1-t_per/100; //Vane Thickness
  Factor
19 //As Outer Diameter= 2 times the Inner
  Diameter ,

```



```

20             Do_by_Di=2;           //Do/Di
21
22
23 //Data Required:-
24     rho=1000;           //Density of Water, Kg/m^3
25     g=9.81;           //Acceleration due to gravity, m/
                s^2
26
27 //Computations:-
28     Vfi=Kf*sqrt(2*g*H);       //m/s
29     Vfo=Vfi;
30     Q=P*1000/(rho*g*H*eta_o); //m^3/s
31
32             Do=sqrt(Q/(Kt*%pi*bo_by_Do*Vfi));
                //m
33             Di=Do/Do_by_Di;       //m
34             bo=Do*bo_by_Do*1000; //mm
35             bi=Do*bo/Di;          //mm
36
37             ui=%pi*Do*N/60;       //m/s
38             uo=%pi*Di*N/60;       //m/s
39             Vwi=eta_H*g*H/ui;     //m/s
40
41 // (a) Guide Vane Angle, alpha_i
42             alpha_i=atand(Vfi/Vwi); //
                degrees
43
44 // (b) Runner Vane Angles at Inlet and Outlet,
                beta_i ,beta_o
45             beta_i=atand(Vfi/(Vwi-ui)); //
                Runner Vane Angle at Inlet ,
                degrees
46             beta_o=atand(Vfo/uo); //Runner
                Vane Angle at Outlet , degrees
47
48
49 // (c) Diameter of Runner at Inlet ant Outlet ,
                Do and Di .

```

```

50                                     //Calculated Above
51
52     // (d) Width of Wheel at Inlet , bi.
53                                     //Calculated Above
54
55 //Results:-
56     printf(" (a)Guide Vane Angle,   alpha_i=%0.2 f
           Degrees\n ",alpha_i)           //The Answer
           Vary due to Round off Error
57
58     printf(" (b)Runner Vane Angles at Inlet and
           Outlet are:- \n           beta_i=%0.2 f Degrees ,
           beta_o =%0.2 f Degrees \n",beta_i,beta_o)
           //The Answer Vary due to Round off
           Error
59
60     printf(" (c)Diameter of Runner at Inlet and
           Outlet are: \n           Do=%0.4 f m           Di
           =%0.4 f m \n",Do ,Di)           //The Answer(Do)
           Vary due to Round off Error
61     printf(" (d) Width of Wheel at Inlet , bo=%0.2 f mm
           \n",bo )           //The Answer Vary due to
           Round off Error

```

Scilab code Exa 5.6 To Find a Guide Blade Angles b Blade Angle at Inlet c Power De

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 5– Francis Turbine
3 //Example 5.6
4 //To Find (a) Guide Blade Angles (b) Blade
   Angle at Inlet (c) Power Developed
5
6     clc
7     clear
8

```

```

9 //Given Data:-
10     Q=300; //Discharge , litres/s
11     Di=0.36; //Diameter of Runner at
        Outlet , m
12     Dp=Di; //Diameter of Outlet Pipe ,
        m
13     H=36; //Head, m
14     ui=21; // Velocity of Wheel at
        Inlet , m/s
15
16 //Data Required:-
17     rho=1000; //Density of water , Kg/m^3
18     g=9.81; //Acceleration due to
        gravity , m/s^2
19
20 //Computations:-
21     Vfo=(Q/1000)/((%pi/4)*Di^2); //m/s
22     Vo=Vfo;
23     Vfi=Vfo;
24 //By Energy Balance Equation ,
25     Vwi=(g*H-Vo^2/2)/ui; //m/s
26
27 // (a) Guide Blade Angles , alpha_i , alpha_o
28     alpha_i=atand(Vfi/Vwi); //degrees
29 //As Discharge is Radial ,
30     alpha_o=90; //degrees
31
32 // (b) Blade Angle at Inlet , beta_i
33     beta_i=180-atand(Vfi/(ui-Vwi)); //
        degrees
34
35 // (c) Power Developed by Runner
36     P=rho*(Q/1000)*Vwi*ui/1000; //kW
37
38 //Results:-
39     printf(" (a) Guide Blade Angles are: \n
        alpha_i=%0.2f Degrees , alpha_o=%0.
        f Degrees\n",alpha_i , alpha_o )

```

```

40     printf(" (b) Blade Angle at Inlet , beta_i=%0.2f
        Degrees\n",beta_i)
41     printf(" (c) Power Developed by Runner , P =%0.2
        f kW\n",P)          //The Answer Vary due to
        Round off Error

```

Scilab code Exa 5.7 To Determine a The Diameter of Wheel b The Quantity of Water S

```

1 //Fluid Systems– By Shiv Kumar
2 //Chapter 5– Francis Turbine
3 //Example 5.7
4 //To Determine (a) The Diameter of Wheel (b) The
    Quantity of Water Supplied (c) The Guide Blade
    Angle at Inlet (d) The Runner Vane Angles
    at Inlet and Exit.
5
6     clc
7     clear
8
9 //Given Data:–
10     P=368;          //Shaft Power , kW
11     H=71;          //Head , m
12     N=748;         //Speed , rpm
13     bo_by_Do=0.1; //Breadth Ratio
14     Kf=0.15;       //Flow Ratio
15     eta_H=95/100;  //Hydraulic Efficiency
16     eta_m=85/100;  //Mechanical Efficiency
17     eta_v=100/100; //Volumetric Efficiency (
        Assumed to be 100%)
18
19 //As Inner Diameter is Half the Outer
    Diameter ,
20     Di_by_Do=1/2; //Di/Do
21
22

```

```

23 //Data Required:-
24     rho=1000;           //Density of Water, Kg/m^3
25     g=9.81;           //Acceleration due to gravity, m/
                        s^2
26
27 //Computations:-
28     eta_o=eta_H*eta_m*eta_v;           // Overall
                        Efficiency
29     Q=P*1000/(rho*g*H*eta_o);           //m^3/s
30     Vfi=Kf*sqrt(2*g*H);               //m/s
31     Vfo=Vfi;
32     Do=sqrt(Q/(%pi*bo_by_Do*Vfi));
                        //m
33     Di=Do*Di_by_Do;                   //m
34
35     // (a) The Diameter of Wheel, Do
36         // Calculated Above
37
38     // (b) The Quantity of Water Supplied , Q
39         // Calculated Above
40
41     // (c) The Guide Blade Angle at Inlet , alpha_i
42
43     ui=%pi*Do*N/60;                   //m/s
44     uo= %pi*Di*N/60;                   //m/s
45     Vwi=eta_H*g*H/ui;                   //m/s
46     alpha_i=atand(Vfi/Vwi);           //degrees
47
48     // (d) Runner Vane Angles at Inlet and Outlet ,
49     beta_i , beta_o
50     beta_i=atand(Vfi/(Vwi-ui));         //
                        Runner Vane Angle at Inlet ,
                        degrees
51     beta_o=atand(Vfo/uo);               //Runner
                        Vane Angle at Outlet , degrees
52
53 //Results:-

```

```

54     printf(" (a) The Diameter of Wheel, Do =%.3 f m\n
        ",Do )
55     printf(" (b) The Quantity of Water Supplied , Q=%.
        .4 f m^3/s\n",Q )
56     printf(" (c) The Guide Blade Angle at Inlet ,
        alpha_i=%.2 f Degrees\n",alpha_i )           //
        The Answer Vary due to Round off Error
57     printf(" (d)Runner Vane Angles at Inlet and
        Outlet are:- \n          beta_i=%.2 f Degrees ,
        beta_o =%.2 f Degrees \n",beta_i,beta_o )
        //The Answer Vary due to Round off
        Error

```

Scilab code Exa 5.8 Theoretical Problem

```

1 //Fluid Systems– By Shiv Kumar
2 //Chapter 5– Francis Turbine
3 //Example 5.8
4 //Theoretical Problem .

```

Scilab code Exa 5.9 To Find i Guide Blade Angle at Inlet ii The Wheel Vane Angle a

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 5– Francis Turbine
3 //Example 5.9
4 //To Find (i) Guide Blade Angle at Inlet (ii)
  The Wheel Vane Angle at Inlet (iii) Diameter
  of Wheel at inlet (iv)Width of Wheel at
  Inlet
5
6     clc
7     clear
8

```

```

9 //Given Data:-
10 //Data Required
11 rho=1000; //Density of water, Kg/m^3
12 g=9.81; //Acceleration due to
gravity , m/s^2
13
14 eta_o=76/100; //Overall Efficiency
15 P=150; //Power Produced, kW
16 H=8; // Working Head, m
17 ui=0.25*sqrt(2*g*H); //Peripheral
Velocity at Inlet , m/s
18 Vfi=0.95*sqrt(2*g*H); //Velocity of
Flow at Inlet , m/s
19 N=150; //Speed, rpm
20 H_loss=20; //Percentage of
Hydraulic Losses in the Turbine (of
Available Energy)
21 //As Discharge is Radial,
22 alpha_o=90; //Degrees //Vfo=
Vo
23 Vwo=0;
24
25 //Computations:-
26 Do=ui*60/(%pi*N); //m
27 Q=P*1000/(rho*g*H*eta_o); //m^3/s
28 bo=Q/(%pi*Do*Vfi); //m
29
30 //By Energy Balance Equation ,
31 Vwi=(g*H-(H_loss/100)*g*H)/ui; //m/s
32
33 alpha_i=atand(Vfi/Vwi); //degrees
34 beta_i=atand(Vfi/(Vwi-ui)); //
degrees
35
36
37 //Results:-
38 printf(" (i) Guide Blade Angle at Inlet ,
alpha_i=%.2f Degrees\n",alpha_i) //

```

```

    The Answer Vary due to Round off Error
39  printf(" (ii) The Wheel Vane Angle at Inlet ,
    beta_i =%.2f Degrees\n", beta_i )
    //The Answer Vary due to Round off Error
40  printf(" (iii) Diameter of Wheel at Inlet , Do
    =%.4f m\n", Do)          //The Answer Vary
    due to Round off Error
41  printf(" (iv) Width of Wheel at Inlet , bo =%.4
    f m\n", bo)

```

Scilab code Exa 5.10 To Find i Guide Blade Angle at Inlet ii The Wheel Vane Angle

```

1  //Fluid Systems – By Shiv Kumar
2  //Chapter 5– Francis Turbine
3  //Example 5.10
4  //To Determine (i) The Guide Blade Angle (ii)
    The Wheel Vane Angle at Inlet (iii) Diameter
    of Wheel at inlet (iv) Width of Wheel at
    Inlet
5
6  clc
7  clear
8
9  //Given Data:–
10 //Data Required
11 rho=1000; //Density of water, Kg/m^3
12 g=9.81; //Acceleration due to
    gravity , m/s^2
13
14 eta_o=75/100; //Overall Efficiency
15 P=148.25; //Power Produced, kW
16 H=7.62; // Working Head, m
17 ui=0.26*sqrt(2*g*H); //Peripheral
    Velocity at Inlet, m/s
18 Vfi=0.96*sqrt(2*g*H); //Velocity of

```



```

                                Flow at Inlet , m/s
19      N=150;                      //Speed , rpm
20      H_loss=22;                  //Percentage of
                                Hydraulic Losses in the Turbine (of
                                Available Energy)
21      //As Discharge is Radial ,
22      alpha_o=90;                //Degrees                //Vfo=
                                Vo
23      Vwo=0;
24
25      //Computations:-
26      Do=ui*60/(%pi*N);          //m
27      Q=P*1000/(rho*g*H*eta_o);  //m^3/s
28      bo=Q/(%pi*Do*Vfi);        //m
29
30      //By Energy Balance Equation ,
31      Vwi=(g*H-(H_loss/100)*g*H)/ui; //m/s
32
33      alpha_i=atand(Vfi/Vwi);    //degrees
34      beta_i=atand(Vfi/(Vwi-ui)); //
                                degrees
35
36
37      //Results:-
38      printf(" (i)The Guide Blade Angle , alpha_i=%
0.2f Degrees\n",alpha_i)
39      printf(" (ii) The Wheel Vane Angle at Inlet ,
beta_i =%0.2f Degrees\n", beta_i ) //
                                The Answer Vary due to Round off Error
40      printf(" (iii) Diameter of Wheel at Inlet , Do
=%0.4f m\n",Do) //The Answer Vary due
to Round off Error
41      printf(" (iv)Width of Wheel at Inlet , bo =%0.4
f m\n",bo) //The Answer Vary due to
Round off Error

```

Scilab code Exa 5.11 To Determine The Flow Rate Guide Vane Angles Runner Vane Angl

```
1 //Fluid Systems– By Shiv Kumar
2 //Chapter 5– Francis Turbine
3 //Example 5.11
4 //To Determine The Flow Rate, Guide Vane Angles,
   Runner Vane Angles and Inner and Outer Diameters
   of the Runner.
5
6     clc
7     clear
8
9 //Given Data:–
10     H=86.4;           //Net Head, m
11     N=650;           //Speed, rpm
12     P=397;           //Shaft Power, kW
13     bo_by_Do=0.1;    //Breadth Ratio
14     Di_by_Do=0.5;    //Di/Do
15     Kf=0.17;         //Flow Ratio
16     eta_H=95/100;    //Hydraulic Efficiency
17     eta_o=85/100;    //Overall Efficiency
18     //As Discharge is Radial and Flow Velocity is
       Constant,
19     alpha_o=90;     //degrees           //Vfi=
       Vfo=Vo
20
21
22 //Data Required:–
23     rho=1000;        //Density of Water, Kg/m^3
24     g=9.81;         //Acceleration due to gravity, m/
       s^2
25
26 //Computations:–
27     Q=P*1000/(rho*g*H*eta_o);           //m^3/s
```

```

28     Vfi=Kf*sqrt(2*g*H);           //m/s
29     Vfo=Vfi;
30     Do=sqrt(Q/(%pi*bo_by_Do*Vfi));
        //m
31     Di=Do*Di_by_Do;               //m
32     ui=%pi*Do*N/60;               //m/s
33     uo= %pi*Di*N/60;              //m/s
34     Vwi=eta_H*g*H/ui;             //m/s
35     alpha_i=atand(Vfi/Vwi);       //
        degrees
36     beta_i=atand(Vfi/(Vwi-ui));   //
        Runner Vane Angle at Inlet ,
        degrees
37     beta_o=atand(Vfo/uo);         //Runner
        Vane Angle at Outlet , degrees
38
39
40 //Results:-
41 printf(" (i) The Flow Rate, Q=%0.3f m^3/s\n",Q )
42 printf(" (ii) Guide Vane Angles are: \n
        alpha_i=%0.2f Degrees , alpha_o=%0.f Degrees\n
        n",alpha_i,alpha_o)         //The Answer Vary
        due to Round off Error
43 printf(" (iii) Runner Vane Angles are:- \n
        beta_i=%0.2f Degrees , beta_o =%0.2f
        Degrees \n",beta_i,beta_o ) //The
        Answer Vary due to Round off Error
44 printf(" (iv) Inner and Outer Diameters of the
        Runner are: \n Di=%0.2f m , Do=%0.2
        f m \n",Di,Do )

```

Scilab code Exa 5.12 To Determine a Overall Efficiency b The Direction of Flow rel

```

1 //Fluid Systems– By Shiv Kumar
2 //Chapter 5– Francis Turbine

```

```

3 //Example 5.12
4     clc
5     clear
6
7 //Given Data:-
8         Dp=5;           //Diameter at Penstock , m
9         P=61000;       //Output Power, kW
10        Q=110;         //Discharge , m^3/s
11        N=160;        //Speed, rpm
12        eta_H=94/100;  //Hydraulic
                    Efficiency
13        Do=4;          //Diameter of Runner at
                    Inlet , m
14        bo=1;         //Width of Runner at
                    Inlet , m
15        Ddi=4.2;      //Entry Diameter to Draft
                    Tube, m
16        V2=2.2;       //Velocity in Tail Race, m
                    /s
17        p_by_rho_g=58; //Static Pressure
                    Head (p/(rho*g)) , m
18        Z=2.8;        //Level of Measurement above
                    Tail Race, m
19        loss=25;      //Percentage of loss in
                    Draft Tube (of Velocity Head at its
                    Entry)
20        Z1=2.2;       //Level of Runner Exit
                    above Tail Race, m
21
22 //Data Required:-
23        rho=1000;     //Density of Water, Kg/m^3
24        g=9.81;      //Acceleration due to gravity
                    , m/s^2
25
26 //Computations:-
27        Vp=4*Q/(%pi*Dp^2); //Velocity in
                    Penstock , m/s
28        Vo=4*Q/(%pi*Ddi^2); //Velocity at

```

```

                Entry to the Draft Tube, m/s
29      Hp=p_by_rho_g+Z+Vp^2/(2*g);           //Head
                just before Entry to Runner, m
30      H=Hp-V2^2/(2*g);                     //Working Head, m
31
32      //(a) Overall Efficiency
33      eta_o=P*1000/(rho*Q*g*H)*100;        //
                In Percentage
34
35      //(b) The Direction of Flow relative to the
                Runner at Inlet
36      ui=%pi*Do*N/60;                      //m/s
37      Vwi=eta_H*g*H/ui;                   //m/s
38      Vfi=Q/(%pi*Do*bo);                 //m/s
39      beta_i=180-atan(Vfi/(ui-Vwi));
                //degrees
40
41      //(c) The Pressure Head at entry to Draft Tube
                , p1/(rho*g)
42      //By Applying Bernoulli's Equation with
                ,
43      Z2=0;
44      p2_by_rho_g=0;
45      hf=(loss/100)*Vo^2/(2*g);
46
47      p1_by_rho_g=p2_by_rho_g+(V2^2-Vo^2)/(2*g)
                +(Z2-Z1)+hf;           //m
48
49
50 //Results:-
51      printf("(a)The Overall Efficiency , eta_o=%0.2f
                Percent\n",eta_o)           //The Answer Vary
                due to Round off Error
52      printf("(b)The Direction of Flow relative to
                the Runner at Inlet , beta_i=%0.2f Degrees \n"
                ,beta_i)                   //The Answer Vary due to
                Round off Error
53      printf("(c) The Pressure Head at entry to Draft

```

```

    Tube,    p1/(rho*g)=%.2 f m (vaccum)\n", abs(
    p1_by_rho_g))

```

Scilab code Exa 5.13 To Determine the Blade Angle at Entry and Exit

```

1 //Fluid Systems– By Shiv Kumar
2 //Chapter 5– Francis Turbine
3 //Example 5.13
4 //To Determine the Blade Angle at Entry and Exit.
5
6     clc
7     clear
8
9 //Given Data:–
10         R=0.6;           //Degree
11         ui=15;          //Peripheral velocity of
12             Runner at entry, m/s
13         Vfo=3.2;        //m/s
14         Vfi=Vfo;
15         Vo=Vfo;
16         //As the Diameter of rotor at entry is Twice
17             that at exit ,
18             Do_by_Di=2;
19 //Computations:–
20         Vwi=(1-R)*2*ui; //m/s
21         beta_i=180-atan(Vfi/(ui-Vwi));
22             //degrees
23         uo=ui/Do_by_Di; //Velocity of
24             Runner at Outlet, m/s
25         beta_o=atan(Vfo/uo); //
26             degrees

```

```

26 //Results:-
27     printf("The Blade Angle at Entry , beta_i=%0.2 f
           Degrees\n",beta_i)           //The Answer Vary
           due to Round off Error
28     printf("The Blade angle at Exit , beta_o=%0.3 f
           Degrees \n",beta_o)

```

Scilab code Exa 5.14 To Find the Pressure Head at the Entrance

```

1 //Fluid Systems- By Shiv Kumar
2 //Chapter 5- Francis Turbine
3 //Example 5.14
4 //To Find the Pressure Head at the Entrance.
5
6     clc
7     clear
8
9 //Given Data:-
10     Vo=5.6;           //Velocity at Inlet , m/s
11     Vd=1.4;          //Velocity at Outlet , m/s
12     h_f=0.12;        //Friction Losses , m
13     Ho=5.2;          //Vertical Height between
                       tail-race and entrance of Draft-tube,
                       m
14
15 //Data Required:-
16     g=9.81;          //Acceleration due to gravity , m/s^2
17
18 //Calculations:-
19     //Applying Bernoulli 's Equation with ,
20     Z2=0;
21     pa_by_rho_g=0;
22     p1_by_rho_g=pa_by_rho_g+(Vd^2-Vo^2)/(2*
                       g)+Z2-Ho+h_f;           //m
23

```

```

24 //Results:-
25     printf("The Pressure Head at Entrance ,
           p1/(rho*g)=%.3f m\n" , p1_by_rho_g)

```

Scilab code Exa 5.15 To Find a Pressure Head at Tube Entrance b Efficiency of Draft

```

1 //Fluid Systems– By Shiv Kumar
2 //Chapter 5– Francis Turbine
3 //Example 5.15
4     clc
5     clear
6
7 //Given Data:-
8     Vo=4.5;           //Velocity of water at Tube
                       Entrance , m/s
9     D1=0.4;          //Diameter of Tube at Upper
                       End, m
10    D2=0.65;         //Diameter of Tube at Lower
                       End, m
11    l=4.8;           //Length of Tube, m
12    h_f=0.14;        //Head Losses due to
                       Friction , m
13    h=1;             //Length of Tube immersed
                       in Tail-race , m
14
15 //Data Required:-
16    pa=1.013e5;      //Air (Atmospheric)
                       Pressure , Pa
17    rho=1000;        //Density of Water, Kg/m^3
18    g=9.81;          //Acceleration due to
                       gravity , m/s^2
19
20 //Calculations:-
21    A1=(%pi/4)*D1^2; //Cross-sectional
                       Area at Upper End, m^2

```



```

22         A2=(%pi/4)*D2^2;          //Cross-sectional
           Area at Lower End, m^2
23     //Using Continuity Equation,
24         Vd=A1*Vo/A2;             //Velocity of Water
           at Outlet, m/s
25
26     //(a) Using Bernoulli's Equation,
27         p1_by_rho_g=pa/(rho*g)+h+(Vd^2-Vo^2)/(2*g
           )-1+h_f;                //Absolute Pressure Head
           at Inlet, m
28
29         //For Vaccum Pressure Head,
30         pa_by_rho_g=0;
31         p1_by_rho_g_v=pa_by_rho_g+h+(Vd^2-Vo^2)
           /(2*g)-1+h_f;           //Vaccum Pressure
           Head at Inlet, m
32
33     //(b) Efficiency of Draft Tube:
34         eta_d=(Vo^2-Vd^2-2*h_f*g)*100/Vo^2;
           //In Percentage
35
36 //Results:-
37     printf("(a)The Pressure Head at Tube Entrance
           is\n\t")
38     printf(" p1/(rho*g)=%0.3f m (Absolute)\n\t p1/(
           rho*g)=%0.3f m (Vaccum)\n ",p1_by_rho_g,
           p1_by_rho_g_v)          //The Answer Vary due
           to Round off Error
39     printf("(b) Efficiency of Draft Tube, eta_d=%0.2f
           Percent\n",eta_d)       //The Answer Vary
           due to Round off Error

```

Chapter 6

Kaplan and Propeller Turbines

Scilab code Exa 6.1 To Find a Discharge b Diameter of Hub And Diameter of Runner c

```
1 //Fluid System By Shiv Kumar
2 //Chapter 6 – Kaplan and Propeller Turbines
3 //Example 6.1
4 //To Find (a) Discharge (b) Diameter of Hub And
   Diameter of Runner (c) Speed
5
6     clc
7     clear
8
9 //Given:
10    P=37; //Shaft Power, MW
11    H=22; //Head, m
12    eta_0=92/100; //Overall Efficiency
13    dbyD=1/3; //Ratio of Diameters of Hub and
   Runner
14    Kf=0.6; //Flow Ratio
15    Ku=2; //Speed Ratio
16 //Data Required:
17    rho=1000; //Density of Water, Kg/m^3
18    g=9.81; //Acceleration due to gravity, m/s^2
19
```

```

20 // Computations
21
22 //(a) Discharge , Q
23     Q=P*10^6/(rho*g*H*eta_0);    //m^3/s
24
25 //(b) Diameter of Hub(d) And Diameter of Runner(D)
26     d=sqrt(Q/((%pi/4)*Kf*sqrt(2*g*H)*(dbyD^-2-1)))
27     ;    //m
28     D=d/dbyD;    //m
29
30 //(c) Speed ,N
31     N=Ku*60*sqrt(2*g*H)/(%pi*D);    // rpm
32
33 // Results
34 printf(" (a) Discharge , Q=%0.2 f m^3/s \n" ,Q)    //The
35     answer vary due to round off error
36 printf(" (b) Diameter of Hub, d=%0.2 f m \n" ,d)
37 printf("    Diameter of Runner , D=%0.2 f m \n" ,D)
38     //The answer vary due to round off error
39 printf(" (c) Speed , N=%0.2 f rpm \n" ,N)    //The
40     answer vary due to round off error

```

Scilab code Exa 6.2 To Find Diameter of Runner Speed of Runner and Specific Speed

```

1 //Fluid System By Shiv Kumar
2 //Chapter 6 – Kaplan and Propeller Turbines
3 //Example 6.2
4 //To Find Diameter of Runner , Speed of Runner and
5     Specific Speed of Turbine
6
7     clc
8     clear
9
10 //Given:
11     P=8;    //Shaft Power , MW

```

```

11     H=6;      //Head, m
12     Ku=2.09;      //Speed Ratio
13     Kf=0.68;      //Flow Ratio
14     eta_0=90/100; //Overall Efficiency
15     dbyD=1/3;    //Ratio of Diameters of Hub and
        Runner
16
17 //Data Required:
18     rho=1000;    //Density of Water, Kg/m^3
19     g=9.81;     //Acceleration due to gravity, m/s^2
20
21 //Computations
22
23     Q=P*10^6/(rho*g*H*eta_0); //Discharge, m^3/s
24     d=sqrt(Q/((%pi/4)*Kf*sqrt(2*g*H)*(dbyD^-2-1)));
        //Diameter of hub, m
25     D=d/dbyD; //Diameter of runner, m
26     N=Ku*60*sqrt(2*g*H)/(%pi*D); //Speed of Runner
        , rpm
27     Ns=N*(P*10^3)^(1/2)/(H^(5/4)); //Specific
        Speed of Turbine, SI Units
28
29 //Results
30     printf("Diameter of Runner, D =%.1f m \n",D)
31     printf("Speed of Runner, N = %.2f rpm \n",N) //
        The answer provided in the textbook is wrong
32     printf("Specific Speed of Turbine, Ns = %.2f (SI
        Units)",Ns) //The answer provided in the
        textbook is wrong(Due to error in N)

```

Scilab code Exa 6.3 To Find a Inlet and Outlet blade Angles b Mechanical Efficiency

```

1 //Fluid System By Shiv Kumar
2 //Chapter 6 – Kaplan and Propeller Turbines
3 //Example 6.3

```

```

4 //To Find (a) Inlet and Outlet blade Angles (b)
   Mechanical Efficiency (c) Volumetric Efficiency
5
6     clc
7     clear
8
9 //Given:
10    D=6;      //Outer Diameter of Runner, m
11    d=2;      //Inner Diameter of Runner, m
12    P=30;     //Shaft Power, MW
13    N=75;     //Speed, rpm
14    H=12;     //Head, m
15    Q=310     //Discharge through the Runner, m3/s
16    eta_H=96/100; //Hydraulic Efficiency
17
18 //Data Required:
19    rho=1000; //Density of Water, Kg/m3
20    g=9.81;   //Acceleration due to gravity, m/s2
21
22 //Computations
23
24    u=%pi*D*N/60; //Velocity of runner, m/s
25    ui=u;
26    uo=u;
27    Vf=Q/((%pi/4)*(D2-d2)) // m/s
28    Vfi=Vf;
29    Vfo=Vf;
30    Vwi=eta_H*g*H/ui; // m/s //The Answer Vary
   Because Value of ui used in book is Wrong
31
32 //(a) Inlet and Outlet blade Angles, Beta_i and
   Beta_o
33
34    Beta_i=180-atan(Vfi/(ui-Vwi)); //Degrees
35    Beta_o=atan(Vfo/uo); //Degrees
36
37 //(b) Mechanical Efficiency, eta_m
38

```

```

39     eta_M=P*10^6/(rho*Q*Vwi*ui)*100;    //percentage(
        %)    //The Answer Vary Because Value of Vwi
        used in book is Wrong
40
41 // (c) Volumetric Efficiency , eta_v
42
43     eta_o=P*10^6/(rho*Q*g*H)*100;    // Overall
        Efficiency , percentage (%)
44     eta_v=eta_o/(eta_M*eta_H);    //percentage (%)
        //The Answer Vary Because Value of eta_m used
        in book is Wrong
45
46 // Results
47
48     printf("(a) Inlet Blade Angle , Beta_i=%0.2f degrees
        and \n",Beta_i)    //The answer vary due to
        round off error
49     printf("    Outlet Blade Angle , Beta_o=%0.2f degrees
        \n",Beta_o)    //The answer vary due to round
        off error
50     printf("(b) Mechanical Efficiency , eta_m=%0.2f
        percent\n",eta_M)    //The answer provided in
        the textbook is wrong
51     printf("(c) Volumetric Efficiency , eta_v=%0.2f
        percent\n ",eta_o)    //The answer provided in
        the textbook is wrong

```

Scilab code Exa 6.4 To Find a Discharge b Hydraulic Efficiency c Overall Efficiency

```

1 //Fluid System By Shiv Kumar
2 //Chapter 6 – Kaplan and Propeller Turbines
3 //Example 6.4
4 //To Find (a) Discharge (b) Hydraulic Efficiency (c)
    Overall Efficiency (d) Specific Speed
5

```

```

6   clc
7   clear
8
9   //Given:
10  N=30    //Speed , rpm
11  Alpha_i=31;    //Inlet Guide Vane Angle ,
        Degrees
12  Beta_i=90;    //Inlet Runner Vane Angle ,
        Degrees
13  Beta_o=24;    //Outlet Runner Vane Angle ,
        Degrees
14  Dm=4;    //Mean Diameter of Runner , m
15  A=31;    //Area of Flow , m^2
16  ML=5;    //Percent of Mechanical Loss
17  //Data Required:
18  rho=1000;    //Density of Water , Kg/m^3
19  g=9.81;    //Acceleration due to gravity , m/s^2
20
21  //Computations
22
23  u=%pi*Dm*N/60;    //Velocity of runner , m/s
24  ui=u;
25  uo=u;
26  Vwi=ui;
27  Vf=ui*tand(Alpha_i);    //m/s
28  Vf=Vf;
29  Vfo=Vf;
30  Vrwo=Vfo/tand(Beta_o);    //m/s
31  Vwo=Vrwo-uo;
32  Vo=sqrt(Vfo^2+Vwo^2);    //m/s
33  //(a) Discharge , Q
34  Q=A*Vf;    //m^3/s
35  //(b) Hydraulic Efficiency , eta_H
36  H= (Vwi+Vwo) *u/g+Vo^2/(2*g);    // Head , m
37  eta_H=(Vwi*ui+Vwo*uo)*100/(g*H);    //Percent (%)
38  //(c) Overall Efficiency , eta_o
39  P=rho*Q*(Vwi+Vwo)*u*(1-ML/100);    //Shaft

```

```

                Power,   Watt(w)
40      eta_o=P/(rho*Q*g*H)*100;           //Percent (%)
41 // (d) Specific Speed, Ns
42      Ns=N*sqrt(P/1000)/(H^(5/4));       //SI Units
43
44 //Results
45      printf("(a) Discharge , Q=%0.2f m^3/s\n",Q) //The
        answer vary due to round off error
46      printf("(b) Hydraulic Efficiency , eta_H =%0.2f
        Percent\n", eta_H) //The answer vary due to
        round off error
47      printf("(c) Overall Efficiency , eta_o =%0.2f
        Percent\n", eta_o) //The answer vary due to
        round off error
48      printf("(d) Specific Speed, Ns =%0.2f (SI Units)\n"
        , Ns) //The answer vary due to round off
        error

```

Scilab code Exa 6.5 To Find a Guide Vane Angle at Inlet b Runner Vane Angle at Inlet

```

1 //Fluid System By Shiv Kumar
2 //Chapter 6 – Kaplan and Propeller Turbines
3 //Example 6.5
4 //To Find (a)Guide Vane Angle at Inlet (b)Runner
    Vane Angle at Inlet
5
6 clc
7 clear
8
9 //Given:
10      P=22500 //Shaft Power, KW
11      H=20; //Head, m
12      N=148; //Speed, rpm
13      eta_H=95/100; //Hydraulic Efficiency
14      eta_o=89/100; //Overall Efficiency

```



```

15     D=4.5;      //Diameter of Runner, m
16     d=2;       //Diameter of Hub, m
17     Beta_o=34  //Runner Vane Angle at Outlet,
           Degrees
18
19 //Data Required:
20     rho=1000;  //Density of Water, Kg/m^3
21     g=9.81;   //Acceleration due to gravity, m/s^2
22
23 //Computations
24
25     u=%pi*D*N/60; //Velocity of runner, m/s
26     Q=P*10^3/(rho*g*H*eta_o); //Discharge, m^3/s
27     Vfi=Q/((%pi/4)*(D^2-d^2)); // m/s
28 //As Velocity of Flow is Constant
29     ui=u;
30     uo=u;
31     Vfo=Vfi;
32     Vf=Vfo;
33     Vrwo=Vfo/tand(Beta_o); //m/s
34     Vwo=uo-Vrwo;
35     Vo=sqrt(Vfo^2+Vwo^2); //m/s
36     Vwi=(g*H-Vo^2/2)/u+Vwo; //m/s
37 //(a)Guide Vane Angle at Inlet,Alpha_i
38     Alpha_i=atand(Vfi/Vwi); //Degrees
39 //(b)Runner Vane Angle at Inlet,Beta_i
40     Beta_i=180-atand(Vfi/(ui-Vwi)); //Degrees
41
42 //Results
43     printf("(a)Guide Vane Angle at Inlet,
           Alpha_i=%0.2f Degrees\n",Alpha_i) //The
           answer vary due to round off error
44     printf("(b)Runner Vane Angle at Inlet, Beta_i
           =%.f Degrees\n",Beta_i) //The answer
           provided in the textbook is wrong

```

Scilab code Exa 6.6 To Find a Diameter of Runner b Speed of Turbine c Specific Spe

```
1 //Fluid System By Shiv Kumar
2 //Chapter 6 – Kaplan and Propeller Turbines
3 //Example 6.6
4 //To Find (a)Diameter of Runner (b)Speed of Turbine
   (c)Specific Speed of the turbine
5
6     clc
7     clear
8
9 //Given:
10    P=9100; //Shaft Power , KW
11    H=5.6; //Net Available Head, m
12    Ku=2.09; //Speed Ratio
13    Kf=0.68; //Flow Ratio
14    eta_0=86/100; //Overall Efficiency
15    dbyD=1/3; //Ratio of Diameters of Hub and
       Runner
16
17 //Data Required:
18    rho=1000; //Density of Water, Kg/m^3
19    g=9.81; //Acceleration due to gravity , m/s^2
20
21 //Computations
22
23    Q=P*10^3/(rho*g*H*eta_0); //Discharge , m^3/s
24
25
26    d=sqrt(Q/((%pi/4)*Kf*sqrt(2*g*H)*(dbyD^-2-1)))
       ; // Diameter of Hub ,m
27 //((i) Diameter of Runner ,D
28    D=d/dbyD; //m
29
```

```

30 // (ii) Speed of Turbine, N
31     N=Ku*60*sqrt(2*g*H)/(pi*D); // rpm
32 // (iii) Specific Speed of Turbine, Ns
33     Ns=N*(P)^(1/2)/(H^(5/4)); // SI Units
34
35
36 // Results
37     printf("(i) Diameter of Runner , D=%.2f m\n",D)
38     printf("(ii) Speed of Turbine, N =%.2f rpm\n",N)
//The answer vary due to round off error
39     printf("(iii) Specific Speed of Turbine, Ns =%.2
f (SI Units)\n",Ns) //The answer provided
in the textbook is wrong(Due to error in N)

```

Scilab code Exa 6.7 To Find a Diameter of Runner b Speed c Specific Speed

```

1 // Fluid System By Shiv Kumar
2 // Chapter 6 – Kaplan and Propeller Turbines
3 // Example 6.7
4 // To Find (a) Diameter of Runner (b) Speed (c)
Specific Speed
5
6 clc
7 clear
8
9 // Given:
10 H=32; // Head, m
11 P=16000; // Shaft Power, KW
12 D_per=190; // Percentage by which Diameter of
Runner(D) is Larger than diameter of Boss(d)
13 eta_0=91/100; // Overall Efficiency
14 Ku=2; // Speed Ratio
15 Kf=0.64; // Flow Ratio
16
17 // Data Required:

```

```

18     rho=1000;    //Density of Water, Kg/m^3
19     g=9.81;     //Acceleration due to gravity, m/s^2
20
21 //Computations
22
23     Vfi=Kf*sqrt(2*g*H);    //Velocity of Flow at
        Inlet, m/s
24     ui= Ku*sqrt(2*g*H);    //Velocity of Runner at
        Inlet, m/s
25
26     Q=P*10^3/(rho*g*H*eta_0);    //Discharge, m^3/s
27
28
29     d=sqrt(Q/((%pi/4)*Kf*sqrt(2*g*H)*((D_per
        /100+1)^2-1)));    // Diameter of Hub ,m
30 //((a) Diameter of Runner ,D
31     D=d+(D_per/100)*d;    //m
32
33 //((b) Speed ,N
34     N=ui*60/(%pi*D);    // rpm
35 //((iii) Specific Speed of Turbine, Ns
36     Ns=N*P^(1/2)/(H^(5/4));    // SI Units
37
38
39 //Results
40     printf("(a)Diameter of Runner , D=%0.3f m\n",D)
41     printf(" (b)Speed, N =%0.2f rpm\n",N)    //The
        answer vary due to round off error
42     printf(" (c) Specific Speed, Ns =%0.2f (SI Units)\
        n",Ns)    //The answer provided in the
        textbook is wrong.

```

Scilab code Exa 6.8 To Find Inlet and outlet Angles of the Runner blades

```
1 //Fluid System By Shiv Kumar
```

```

2 //Chapter 6 – Kaplan and Propeller Turbines
3 //Example 6.8
4 //To Find Inlet and outlet Angles of the Runner
   blades
5
6 clc
7 clear
8
9 //Given:
10 H=25; //Head, m
11 P=23000; //Shaft Power, KW
12 D=5; //External Diameter of Runner, m
13 d=3; //Diameter of Hub, m
14 N=60; //Rotational Speed, rpm
15 eta_H=95/100; //Hydraulic Efficiency
16 eta_0=88/100; //Overall Efficiency
17 Vw=0; //As there is no exit whirl
18
19 //Data Required:
20 rho=1000; //Density of Water, Kg/m^3
21 g=9.81; //Acceleration due to gravity, m/s^2
22
23 //Computations
24 Dm=(D+d)/2; //Mean Diameter of Runner, m
25 ui=%pi*Dm*N/60 //m/s
26 Q=P*10^3/(rho*g*H*eta_0); //Discharge, m^3/s
27 Vfi=Q/((%pi/4)*(D^2-d^2)) // m/s
28 Vwi=eta_H*g*H/ui; //m/s
29 uo=ui;
30 Vfo=Vfi;
31 Beta_i=atand(Vfi/(Vwi-ui)); //Degrees
32 Beta_o=atand(Vfo/uo); //Degrees
33
34 //Results
35 printf("At the Mean Radius\n\t")
36 printf("Runner Blade Angle at Inlet, Beta_i=%
   .2f Degrees\n\t",Beta_i) //The answer
   vary due to round off error

```

```

37     printf("Runner Blade Angle at Outlet , Beta_o=
        %.2f Degrees\n",Beta_o)      //The answer
        vary due to round off error

```

Scilab code Exa 6.9 To Determine Runner Vane Angles at the hub and at the Outer Periphery

```

1 //Fluid System By Shiv Kumar
2 //Chapter 6 – Kaplan and Propeller Turbines
3 //Example 6.9
4 //To Determine Runner Vane Angles at the hub and at
  the Outer Periphery
5
6 clc
7 clear
8
9 //Given:
10 P=22500; //Power Available at Shaft , KW
11 H=20; //Head, m
12 N=150; //Rotational Speed, rpm
13 eta_H=95/100; //Hydraulic Efficiency
14 eta_0=88/100; //Overall Efficiency
15 D=4.5; //Outer Diameter of Runner, m
16 d=2; //Diameter of Hub, m
17 Vw=0; //As there is no exit whirl
18
19 //Data Required:
20 rho=1000; //Density of Water, Kg/m^3
21 g=9.81; //Acceleration due to gravity, m/s^2
22
23 //Computations
24 //Runner Vane Angles at Hub
25 uo=%pi*d*N/60; //m/s
26 ui=uo;
27 Q=P*10^3/(rho*g*H*eta_0); //Discharge , m^3/s
28 Vwi=eta_H*g*H/ui; //m/s

```

```

29         Vfi=Q/((%pi/4)*(D^2-d^2))      // m/s
30     Vfo=Vfi;
31         Beta_i=180-atan(Vfi/(ui-Vwi));    //
           Degrees
32         Beta_o=atan(Vfo/uo);             //Degrees
33
34 //Result1
35     printf("Runner Vane Angles at the Hub \n\t")
36     printf("Beta_i=%0.2f Degrees\n\t",Beta_i)
           //The answer vary due to round off error
37     printf("Beta_o=%0.2f Degrees\n\n",Beta_o)
           //The answer vary due to round off error
38
39     // Runner Vane Angles at outer periphery
40     uo=%pi*D*N/60; //m/s
41         ui=uo;
42         Vwi=eta_H*g*H/ui;                //m/s
43         Beta_i=180-atan(Vfi/(ui-Vwi));    //
           Degrees
44         Beta_o=atan(Vfo/uo);             //Degrees
45
46 //Result2
47     printf("Runner Vane Angles at the Outer
           periphery \n\t")
48     printf("Beta_i=%0.2f Degrees\n\t",Beta_i)
           //The answer vary due to round off
           error
49     printf("Beta_o=%0.2f Degrees\n\n",Beta_o)
           //The answer vary due to round off
           error

```

Scilab code Exa 6.10 To Determine i Hydraulic Efficiency of turbine ii Discharge t

```

1 //Fluid System By Shiv Kumar
2 //Chapter 6 – Kaplan and Propeller Turbines

```

```

3 //Example 6.10
4 //To Determine (i)Hydraulic Efficiency of turbine (
      ii)Discharge through the turbine (iii)Power
      Developed by the Runner
5
6 clc
7 clear
8
9 //Given:
10     D=4.5;      // Runner Diameter , m
11     N=48;      // Speed , rpm
12     Alpha_i=145; //Guide Vane Angle at Inlet
      , Degrees
13     Beta_o=25; //Runner blade Angle at
      Outlet
14     A=30;      //Flow Area, m^2
15     //As runner blade angle at inlet is radial
16     Beta_i=90 //Degrees
17
18 //Data Required:
19     rho=1000; //Density of Water, Kg/m^3
20     g=9.81; //Acceleration due to gravity , m/s^2
21
22 //Calculations
23     u=%pi*D*N/60; //Velocity of Runner,m/s
24     ui=u;
25     uo=u;
26     Vwi=ui;
27     Vfi=ui*tand(180-Alpha_i); //m/s
28     Vfo=Vfi;
29     Vrwo=Vfo/tand(Beta_o); //m/s
30     Vwo=Vrwo-uo; //The answer vary because wrong
      Value of uo is used to calculate Vwo in the
      textbook
31     Vo=sqrt(Vfo^2+Vwo^2); //m/s //The answer
      vary because wrong Value of Vwo is used to
      calculate Vo in the textbook
32

```



```

33 // (i) Hydraulic Efficiency , eta_H
34     H= (Vwi-Vwo)*u/g+Vo^2/(2*g);      // Head, m
        //The answer vary because wrong Value
        of Vo and Vwo is used to calculate H in the
        textbook
35     eta_H=(Vwi*ui-Vwo*uo)*100/(g*H);    //Percent(%)
        )
36
37 // (ii) Discharge through the turbine , Q
38     Q=A*Vfi;      //m^3/s
39 // (iii) Power Developed by the Runner , P
40     P=rho*Q*(Vwi-Vwo)*u/10^6;      //MW
41 // Results
42     printf("(i) Hydraulic Efficiency , eta_H=%0.2 f
        Percent\n", eta_H)      //The answer given in
        the textbook is wrong
43     printf("(ii) Discharge through the turbine , Q =%
        .1fm^3/s\n", Q)      //The answer vary due to
        round off error
44     printf("(iii) Power Developed by the Runner , P =%
        .3fMW\n", P)      //The answer given in the
        textbook is wrong

```

Chapter 7

Performance of water turbine

Scilab code Exa 7.1 To Calculate specific speed of turbine and state the type of turbine

```
1 //Fluid Systems by Shiv Kumar
2 //Chapter 7 – Performance of water turbine
3 //Example 7.1
4 //To Calculate specific speed of turbine and state
   the type of turbine
5     clc
6     clear
7 //Given
8     P=8000;           //Power developed , KW
9     H=30;           //Head, m
10    N=140;           //Speed , rpm
11 //Computations
12    Ns=N*P^(1/2)/(H^(5/4));           // specific
   speed of turbine , in SI UNITS
13
14 //Results
15    printf("The Specific speed of Turbine is %.2f
   (SI Units)\n",Ns)
16 //To Determine the type of turbine
17    if Ns>51 & Ns<=255 then
18        printf(" The type of turbine is
```

```

Francis")
19 elseif Ns>=8.5 & Ns<=30 then
20     printf("The type of turbine is Pelton
        Wheel with single jet")
21 elseif Ns>30& Ns<=51 then
22     printf("The type of turbine is Pelton
        Wheel with multi jet")
23 elseif Ns>255 & Ns<=860 then
24     printf("The type of turbine is Kaplan
        or Propeller Turbine")
25 end

```

Scilab code Exa 7.2 To Find a Specific speed of turbine b Power Developed c Type o

```

1 //Fluid Systems by Shiv Kumar
2 //Chapter 7 – Performance of water turbine
3 //Example 7.2
4 //To Find (a) Specific speed of turbine (b) Power
    Developed (c) Type of turbine
5     clc
6     clear
7 //Given:
8
9     H=28;           //Head, m
10    N=225;          //Speed, rpm
11    Q=10;           //Discharge, cumec=m^3/s
12    eta_o=90/100;   //Overall Efficiency
13 //Data Required
14    rho=1000        // Density of Water, Kg/m^3
15    g=9.81;        // Acceleration due to gravity, m/ s
    ^2
16 //Computations
17    P=eta_o*rho*Q*g*H/1000; //Power developed, KW
18    Ns=N*P^(1/2)/(H^(5/4)); // specific speed
    of turbine , in SI UNITS

```

```

19
20 //Result1
21
22     printf("(a)The Specific speed of Turbine = %.2f
        (SI Units)\n",Ns)           //The Answer Vary due
        to Round off Error
23     printf("(b)Power developed =%.2f kW\n",P)
24 //To Determine the type of turbine, Result2
25     if Ns>51 & Ns<=255 then
26         printf("(c)The type of turbine is
                Francis.")
27     elseif Ns>=8.5 & Ns<=30 then
28         printf("(c)The type of turbine is Pelton
                Wheel with single jet.")
29     elseif Ns>30 & Ns<=51 then
30         printf("(c)The type of turbine is Pelton
                Wheel with multi jet.")
31     elseif Ns>255 & Ns<=860 then
32         printf("(c)The type of turbine is
                Kaplan or Propeller turbine.")
33
34     end

```

Scilab code Exa 7.3 To Find a The Discharge required b The Diameter of Wheel c The

```

1 //Fluid Systems by Shiv Kumar
2 //Chapter 7 – Performance of water turbine
3 //Example 7.3
4 //To Find (a) The Discharge required (b) The
    Diameter of Wheel (c) The Diameter and number of
    jets required (d)The Specific Speed
5     clc
6     clear
7 //Given:
8     P=8200; //Power Developed, kW

```

```

9      H=128;      // Head , m
10     N=210;      // Speed , rpm
11     Cv=0.98;    // Co-efficient of Velocity
12     eta_H=89/100; //Hydraulic Efficiency
13     Ku=0.45;    // Speed Ratio
14     dbyD=1/10;  //Ratio of jet diameter to wheel
           Diameter
15     eta_m=92/100; //Mechanical Efficiency
16 //Data required
17     rho=1000;   //Density of Water, Kg/m^3
18     g=9.81;    // Acceleration due to gravity , m/s^2
19 //Assumptions:
20     eta_v=100/100; // Volumetric efficiency is
           100%
21
22 //Computations
23     D=Ku*sqrt(2*g*H)*60/(%pi*N); //Wheel Diameter ,
           m
24     d=D*dbyD;   // Jet diameter , m
25     eta_o=eta_H*eta_m*eta_v; //Overall Efficiency
26     Q=P*1000/(rho*g*H*eta_o); //Net Discharge , m
           ^3/s
27     q=(%pi/4)*d^2*Cv*sqrt(2*g*H); //Discharge
           through one jet , m^3/s
28     n=round(Q/q); //Number of jets
29     Ns= N*P^(1/2)/(H^(5/4)); //Specific Speed ,
           SI Units
30
31 //Results
32 printf("(a) The Discharge required , Q =%.3 f m^3/s\n"
           ,Q)
33 printf("(b) The Diameter of Wheel, D =%.2 f m\n",D)
34 printf("(c) The Diameter , d=%.3 f m and\n
           number of jets required =%. f \n",d,n)
35 printf("(d)The Specific Speed, Ns=%.2 f (SI Units)\n
           ",Ns) //The Answer Vary due to Round off
           Error

```

Scilab code Exa 7.4 To Find a The Diameter of Runner b The Diameter of jet

```

1 //Fluid Systems by Shiv Kumar
2 //Chapter 7 – Performance of water turbine
3 //Example 7.4
4 //To Find (a) The Diameter of Runner (b) The
   Diameter of jet
5     clc
6     clear
7 //Given:
8     P=3200; //Power Developed , kW
9     H=310; // Effective Head , m
10    eta_o=82/100; //Overall Efficiency
11    Ku=0.46; // Speed Ratio
12    Cv=0.98 // Co-efficient of Velocity
13    Ns=18; //Specific Speed (SI Units)
14 //Data required
15    rho=1000; //Density of Water, Kg/m^3
16    g=9.81 // Acceleration due to gravity , m/s^2
17
18 //Computations
19    N=Ns*H^(5/4)/sqrt(P); //Speed , rpm
20    D=Ku*sqrt(2*g*H)*60/(%pi*N); //Diameter of
   runner , m
21    Q=P*1000/(rho*g*H*eta_o); //Discharge , m^3/
   s
22    d=sqrt(Q/((%pi/4)*Cv*sqrt(2*g*H))); //
   Diameter of Jet , m
23
24 //Results
25    printf("(a) The Diameter of Runner , D =%.2 f m\n" ,D
   )
   //The Answer Vary due to Round Off
   Error
26    printf("(c) The Diameter of Jet , d=%.3 f m \n" ,d)

```

Scilab code Exa 7.5 To Find a Number of Units to be installed b Diameter of Wheel

```
1 //Fluid Systems by Shiv Kumar
2 //Chapter 7 – Performance of water turbine
3 //Example 7.5
4 //To Find (a) Number of Units to be installed (b)
   Diameter of Wheel (c) Diameter of Jet
5     clc
6     clear
7
8 //Given:
9
10    H_G= 310; //Gross Head,m
11    l=2.5; // Length, km
12    h_f=25; // Friction Loses, J/N=m
13    T0=20; //Total Output Power, MW
14    N=660; // Speed, rpm
15    ubyVi=0.46 //Ratio of bucket to jet speed
16    eta_o=88/100; //Overall Efficiency
17    Ns=28; //Specific Speed, SI Units
18    Cv=0.97;
19    Cd=0.94;
20
21
22 //Data Required:
23    rho=1000; //Density of water, kg/m^3
24    g=9.81; //Acceleration due to gravity, m/
      s^2
25
26
27 //Computations:
28    H=H_G-h_f; // Effective Head, m
29    P=(Ns*H^(5/4)/N)^2; //Power Output of each Unit
      , KW
```

```

30  //(a) The no. of units to be installed ,n
31  n=round(T0*1000/P);
32  //(b)Diameter of Wheel,D
33  Vi=Cv*sqrt(2*g*H); //m/s
34  D=ubyVi*Vi*60/(%pi*N); //m
35
36  //(c) Diameter of Jet, d
37  Q=T0*10^6/(rho*g*H*eta_o); //Net Discharge, m
    ^3/s
38  q=Q/n; // Discharge through one unit, m^3/s
39  d=sqrt(q/((%pi/4)*Cd*sqrt(2*g*H)))*1000; //mm
40
41
42  //Results
43  printf("(a) The no. of units to be Installed=%0.f
    Units\n",n)
44  printf("(b) Diameter of Wheel, D=%0.3 f m\n",D)
45  printf("(c) Diameter of Jet, d=%0.1 f mm\n",d)
    //The Answer Vary due to round off Error

```

Scilab code Exa 7.6 To Find Speed and Power Developed by the Turbine

```

1  //Fluid Systems by Shiv Kumar
2  //Chapter 7 – Performance of water turbine
3  //Example 7.6
4  //To Find Speed and Power Developed by the Turbine
5      clc
6      clear
7
8  //Given:
9      //Ist Condition
10     P1=8500; //Power Developed, kW
11     N1=120; //Speed, rpm
12     H1=32; //Head, m
13

```



```

14 //2nd Condition
15     H2=25; //Head, m
16
17 //Computations:
18     P2=P1*(H2/H1)^(3/2); //kW
19     N2=N1*(H2/H1)^(1/2); //rpm
20
21 //Results
22     printf("The Speed Developed by the Turbine ,N2=%.f
23           rpm\n",N2)
24     printf("The power developed= %.2 f kW" ,P2)

```

Scilab code Exa 7.7 To Determine unit power unit speed and unit discharge and also

```

1 //Fluid Systems by Shiv Kumar
2 //Chapter 7 – Performance of water turbine
3 //Example 7.7
4 //To Determine unit power, unit speed and unit
5   discharge and also find speed, discharge and
6   power at condition 2
7
8     clc
9     clear
10
11 //Given:
12 //At Condition 1
13     P1=7200; //Power Developed , KW
14     N1=300; //Speed , rpm
15     H1=350; //Head, m
16     eta_o=85/100; // Overall efficiency
17
18 //At Condition 2
19     H2=300; //Head, m
20
21 //Data Used:
22     rho=1000; //Density of Water, kg/m^3

```

```

20     g=9.81;           //Acceleration due to gravity , m/
                        s^@
21
22
23 //Computations:
24     Q1=P1*1000/(rho*g*H1*eta_o);           //m^3/s
25     Pu=P1/(H1^(3/2));           //Unit Power , KW
26     Nu=N1/sqrt(H1);           //Unit Speed , rpm
27     Qu=Q1/sqrt(H1);           //Unit Discharge , m^3/s
28     P2=P1*(H2/H1)^(3/2);           //KW
29     N2=N1*(H2/H1)^(1/2);           //rpm
30     Q2=Q1*sqrt(H2/H1);           //m^3/s
31
32 //Results
33     printf("Unit Power , Pu= %.3 f kW\n Unit Speed , Nu=
        %.2 f rpm\n Unit Discharge , Qu=%.4 f m^/s\n",Pu ,
        Nu , Qu)           //The Answer vary due to Round
        off Error
34
35     printf("At head of 300 m:\n\t")
36     printf("The Speed ,N2=%.2 f rpm\n\t",N2)           //The
        Answer vary due to Round off Error
37     printf("The power ,P2= %.2 f kW\n\t",P2)
38     printf("The Discharge , Q2=%.3 f m^3/s\n",Q2)
        //The Answer vary due to Round off Error

```

Scilab code Exa 7.8 To Find Model Runner Speed and Prototype to Model Scale ratio

```

1 //Fluid Systems– By Shiv Kumar
2 //Chapter 7– Performance of Water Turbine
3 //Example 7.8
4 // To Find Model Runner Speed and Prototype to Model
    Scale ratio
5     clc
6     clear

```

```

7
8 //Given:-
9     //For Prototype
10         Pp=30;           //Power Developed , MW
11         Hp=55;           //Head , m
12         Np=100;          //Speed , rpm
13         Pp=Pp*1000;      //KW
14     //For Model
15         Pm=25 ;          //Power Developed , KW
16         Hm=6;            //Head , m
17
18 //Computations:-
19         Nm=Np*(Hm/Hp)^(5/4)*(Pp/Pm)^(1/2);
20                                 //rpm
21         DpbyDm=((Pp/Pm)*(Nm/Np)^3)^(1/5);
22                                 //A Ratio(Dimensionless)
23         Lr= DpbyDm;         //Scale Ratio
24
25 //Results
26     printf("The Model Runner Speed , Nm=%0.2f rpm And\n",Nm)
27     printf("Prototype to Model Scale Ratio ,Lr=%0.2f",
28         Lr) //The Answer vary due to Round off
29         Error

```

Scilab code Exa 7.9 To Determine the Performance of the Turbine Under a Head of 20

```

1 //Fluid Systems– By Shiv Kumar
2 //Chapter 7– Performance of Water Turbine
3 //Example 7.9
4 // To Determine the Performance of the Turbine Under
5     a Head of 20 m
6     clc
7     clear

```

```

7
8 //Given:-
9     //Condition 1:
10         H1=25;      //Head, m
11         N1=200;    //Speed, rpm
12         Q1=9;      //Discharge, m^3/s
13         eta_o=90/100; //Overall Efficiency
14
15     //Condition 2:
16         H2=20;    //Head, m
17
18 //Data Required:-
19     rho=1000;    //Density of Water, Kg/m^3
20     g=9.81;     //Acceleration due to Gravity,
21                 m/s^2
22
23 //Calculations:-
24     P1=rho*Q1*g*H1*eta_o/1000; //KW
25     N2=N1*sqrt(H2/H1); //rpm
26     Q2=Q1*sqrt(H2/H1); //m^3/s
27     P2=P1*(H2/H1)^(3/2); //KW
28
29
30 //Results:-
31     printf("At Condition 2 (Under a Head of 20 m):\n"
32           )
33     printf("\tSpeed, N2=%0.2f rpm\n\t\t\t\t\t Discharge, Q2=
34           %0.2f m^3/s\n\t\t\t\t\t Power Developed, P2=%0.2f kW"
35           ,N2,Q2,P2) //The Answer vary due to
36           Round off Error

```

Scilab code Exa 7.10 To Calculate Speed and Power Developed by the Prototype when

1 //Fluid Systems– By Shiv Kumar

```

2 //Chapter 7– Performance of Water Turbine
3 //Example 7.10
4 // To Calculate Speed and Power Developed by the
   Prototype when working Under a Head of 8 m.
5     clc
6     clear
7
8 //Given:–
9     Lr=1/5;           //Scale Ratio
10    DmbyDp=Lr;
11
12    //For Prototype
13        Hp=8;       //Head, m
14
15    //For Model
16        Pm=5;       //Power, kW
17        Hm=2;       //Head, m
18        Nm=600;    //rpm
19
20 //Computations
21    Np=Nm*DmbyDp*(Hp/Hm)^(1/2);           //rpm
22    Pp=Pm*(Np/Nm)^3/(DmbyDp^5);         //KW
23
24
25 //Results
26    printf("For the Prototype (Working Under a Head
   of 8 m:\n")
27    printf("          Speed, Np=%f rpm\n          Power
   Developed, Pp=%f kW",Np,Pp)

```

Scilab code Exa 7.11 To Find a Power Developed by Model b Ratio of Heads and Ratio

```

1 //Fluid Systems– By Shiv Kumar
2 //Chapter 7– Performance of Water Turbine
3 //Example 7.11

```

```

4 // To Find (a)Power Developed by Model (b)Ratio
  of Heads and Ratio of Mass Flow Rates between
  Prototype and Model.
5   clc
6   clear
7
8 //Given:-
9   Pp=12;           //Power Developed by Prototype ,MW
10  Lr=1/10;         //Scale Ratio
11  DmbyDp=Lr;
12  LmbyLp=Lr;
13
14
15 //Computations:-
16
17 // (a)Power Developed by the Model
18 //As  $N_p=N_m$  and efficiencies of
   prototype and model are equal
19   Pm=Pp*10^6*(DmbyDp)^5; //W
20
21 // (b)Ratio of Heads and Ratio of Mass flow
   Rates
22   HpbyHm=DmbyDp^(-2); //
   Dimensionless
23   QpbyQm=DmbyDp^(-3)
24   //As  $m=\rho*Q$  and  $\rho$  is Constant. So,
25   m_pbym_m=QpbyQm;
26
27 //Results
28
29   printf("(a)Power Developed by the Model ,Pm=%f W
   \n",Pm)
30   printf(" (b)Ratio of Heads , Hp/Hm=%f\n Ratio
   of Mass flow rates , m_p/m_m=%f\n",HpbyHm ,
   m_pbym_m)

```

Scilab code Exa 7.12 To Find a The Speed Discharge and Power required for the Actua

```

1 //Fluid Systems– By Shiv Kumar
2 //Chapter 7– Performance of Water Turbine
3 //Example 7.12
4 // To Find (a)The Speed ,Discharge and Power
   required for the Actual Pump (b) The Discharge
   of the model.
5 clc
6 clear
7
8 //Given:–
9 Lr=5; //Scale Ratio
10 DpbyDm=Lr;
11 DmbyDp=1/DpbyDm;
12 //For Model
13 Pm=22; //Power Required , kW
14 Hm=7; //Head , m
15 Nm=410; //Speed , rpm
16 eta_m=1; //Assumption that
   efficiency of the model is 100%
17 //For Prototype
18 Hp=35; //Head , m
19 //Data Required:–
20 rho=1000; //Density of Water, Kg/m^3
21 g=9.81; //Acceleration due to gravity ,
   m/s^2
22
23 //Computations:–
24 Np=Nm*DmbyDp*(Hp/Hm)^(1/2); //rpm
25 Pp=Pm*(Np/Nm)^3*DpbyDm^5; //KW
26 Qm=Pm*1000*eta_m/(rho*g*Hm); //m^3/s
27 Qp=Qm*(Np/Nm)^2*DpbyDm^2; //m^3/s
28

```

```

29 //Results:-
30     printf("(a)For the Actual Pump(Prototype):\n
           Speed , Np=%0.2 f rpm   , \n
           Discharge , Qp=%0.3 f m^3/s   and \n
           Power ,Pp=%0.2fKW\n" ,Np ,Qp ,Pp)           //The
           Answer vary due to Round off Error(For Qp
           ), The Answer Provided in the Textbook is
           Wrong (For Np and Pp).
31
32     printf("(b)The Discharge of the Model, Qm=%0.4
           f m^3/s" ,Qm)           //The Answer vary due
           to Round off Error

```

Scilab code Exa 7.13 To Determine the maximum flow rate and specific speed for the

```

1 //Fluid Systems– By Shiv Kumar
2 //Chapter 7– Performance of Water Turbine
3 //Example 7.13
4 // To Determine the maximum flow rate and specific
   speed for the Turbine and To Find Speed, Power
   Output and Water Consumption of the Model.
5     clc
6     clear
7
8 //Given:-
9     Lr=10;           //Scale Ratio
10    DpbyDm=Lr;
11    DmbyDp=1/DpbyDm;
12    //For Prototype
13    Pp=1000;         //Power , kW
14    Hp=14;           //Head, m
15    Np=130;          //Speed , rpm
16    eta_o=91/100;    //Overall efficiency
17    //For Model
18    Hm=6;            //Head, m

```



```

19 //Data Required:-
20     rho=1000; //Density of Water, Kg/m^3
21     g=9.81; //Acceleration due to gravity,
           m/s^2
22
23 //Computations:-
24     Qp=Pp*1000/(rho*g*Hp *eta_o ); //m^3/s
25     Ns=Np*Pp^(1/2)/(Hp^(5/4)); //Specific
           Speed, In SI UNITS
26     Nm=Np*DpbyDm*(Hm/Hp)^(1/2); //rpm
27     Qm=Qp*(Nm/Np)*(DmbyDp)^3; //m^3/s
28     Pm=Pp*(Nm/Np)^3*DmbyDp^5; //KW
29
30 //Results:-
31     printf("For the Turbine : \n\t")
32     printf("Maximum Flow Rate, Qp=%0.2 f m^3/s\n\t"
           ,Qp)
33     printf("Specific Speed, Ns=%0.2 f (SI Units)\n
           \n",Ns)
34     printf("For the Model : \n\t")
35     printf("Speed, Nm=%0.2 f rpm\n           Power
           Output, Pm=%0.2 f kW\n           Water
           Consumption, Qm=%0.4 f m^3/s \n", Nm,Pm,Qm)
           //The Answer vary due to Round off
           Error

```

Scilab code Exa 7.14 To Determine the Size Scale Ratio of the Model and To Find th

```

1 //Fluid Systems– By Shiv Kumar
2 //Chapter 7– Performance of Water Turbine
3 //Example 7.14
4 //To Determine the Size (Scale Ratio) of the Model
   and To Find the Model Speed and Power.
5
6     clc

```

```

7      clear
8
9      //Given:-
10     TP=240000;           //Total Power Produced , kW
11     n=4;                //No. of Turbines
12     eta_o=91/100;       //Effeciency of each
        turbine
13     Np=120;             //Speed of each Turbine , rpm
14     Hp=70;              //Head for each Turbine , m
15
16     Qm=0.45;            //Discharge for Model, m^3/s
17     Hm=5;               //Head for testing the Model,
        m
18
19     //Data Required:-
20     rho=1000;           //Density of Water, Kg/m^3
21     g=9.81;             //Acceleratrion due to
        gravity , m/s^2
22
23     //Calculations:-
24     Pp=TP/n;            //Power produced from each
        Turbine , kW
25     Qp=Pp*1000/(rho*g*Hp*eta_o); //Discharge
        passing through one Turbine , m^3/s
26     DmbyDp=(Qm/Qp)^(1/2)*(Hp/Hm)^(1/4);
        //From Relation of Flow Coefficient
27     Lr=DmbyDp;         //Scale Ratio
28     Nm=(Np/DmbyDp)*(Hm/Hp)^(1/2); //rpm
29     Pm=Pp*(Nm/Np)^3*DmbyDp^5; //KW
30
31     //Results
32     printf("The Scale Ratio is 1:%.2f\n",1/Lr)
33     printf("Model Speed , Nm=%.2f rpm\n",Nm)
34     printf("Model Power , Pm=%.2f kW\n",Pm) //
        The Answer vary due to Round off Error

```

Scilab code Exa 7.15 To Determine the rpm of Prototype Ratio of Power Developed by

```
1 //Fluid Systems– By Shiv Kumar
2 //Chapter 7– Performance of Water Turbine
3 //Example 7.15
4 //To Determine the rpm of Prototype , Ratio of Power
   Developed by Model and Prototype and Efficiency
   of Prototytppe .
5
6   clc
7   clear
8
9 //Given:–
10      Lr=1/8;           //Scale Ratio
11 //For Model ,
12      Hm=5;           //Head, m
13      Nm=350;        //Speed ,rpm
14      eta_m=78/100;   //Efficiency of model
15 //For Prototype ,
16      Hp=100;        //Head, m
17
18 //Calculations:–
19      DpbyDm=1/Lr;    // Dp/Dm
20 // (a) Speed of Prototype , Np
21      Np=Nm*Lr*(Hp/Hm)^(1/2); //rpm
22 // (b) Ratio of Power Developed , Pp/Pm
23      PpbyPm=DpbyDm^5*(Np/Nm)^3;
24 // (c) Efficiency of Prototype when Scale Effect
   is Considered
25 //From Moody's Equation ,
26      eta_p=(1-Lr^0.2*(1-eta_m))*100;
           //In Percentage
27
28 //Results
```

```
29
30 printf(" (a)The Speed of Prototype , Np=%0.2 f rpm\n",
    Np)          //The Answer vary due to Round off
    Error
31 printf(" (b)Ratio of Power Developed , Pp/Pm =%0.2 f \
    n",PpbyPm)    //The Answer vary due to Round
    off Error
32 printf(" (c)Efficiency of Prototype , eta_p =%0.2 f
    Percent\n",eta_p)    //The Answer vary due to
    Round off Error
```

Chapter 11

Centrifugal Pumps

Scilab code Exa 11.1 To Find the Work done by the Impeller on the water per unit w

```
1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.1
4 //To Find the Work done by the Impeller on the water
   per unit weight of water.
5
6     clc
7     clear
8
9 //Given Data:–
10     Di=210;           //Internal diameter of
       Impeller , mm
11     Do=420;           // External diameter of
       Impeller , mm
12     N=1100;           //speed , rpm
13     beta_i=20;        //Vane Angle at Inlet , degrees
14     beta_o=30;        //Vane Angle at Outlet ,
       degrees
15     //As water enters the impeller radially ,
16     alpha_i=90;       //degrees
17
```

```

18
19 //Data Used:-
20     g=9.81;           //Acceleration due to gravity,
                        m/s^2
21
22
23 //Computations:-
24     Di=Di/1000;      //m
25     Do=Do/1000;      //m
26
27     ui=%pi*Di*N/60;   //m/s
28     uo=%pi*Do*N/60;   //m/s
29     Vfi=ui*tand(beta_i); //m/s
30     Vfo=Vfi;
31     Vwo=uo-Vfo/tand(beta_o); //m/s
32     Work=Vwo*uo/g;    //N-m/N
33
34 //Result:-
35     printf(" The Work done by the Impeller on the
            water per unit weight of water =%.2f N-m/N
            \n",Work) //The answer vary due to
            round off error

```

Scilab code Exa 11.2 To Find the Vane Angle at Outer Periphery of the Impeller

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.2
4 //To Find the Vane Angle at Outer Periphery of the
  Impeller.
5
6     clc
7     clear
8
9 //Given Data:-

```

```

10     N=1470;           //Speed , rpm
11     Q=100;           //Discharge , litres/s
12     Hm=24;           //manometric Head, m
13     Do=240;          // Diameter of Impeller at
                        Outlet , mm
14     b_o=50;          //Width of Impeller at Outlet ,
                        mm
15     eta_man=76/100;  //Manometric
                        Efficiency
16
17
18 //Data Used:-
19     g=9.81;          //Acceleration due to gravity ,
                        m/s^2
20
21
22 //Computations:-
23     Q=Q/1000;        //m^3/s
24     Do=Do/1000;      //m
25     b_o=b_o/1000;    //m
26
27     uo=%pi*Do*N/60;  //m/s
28     Vwo=g*Hm/(uo*eta_man); //m/s
29     Vfo=Q/(%pi*Do*b_o); //m/s
30 //From Outlet Velocity Triangle (OVT),
31     beta_o=atand(Vfo/(uo-Vwo)); //degrees
32
33 //Result:-
34     printf("The Vane Angle at Outer Periphery of
        Impeller , beta_o=%.2f Degrees \n",beta_o)
        //The answer vary due to round off
        error

```

Scilab code Exa 11.3 To Find the Power of the Pump

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.3
4 //To Find the Power of the Pump.
5
6     clc
7     clear
8
9 //Given Data:–
10     H=40;           //Total Head, m
11     Q=50;           //Discharge, litres/s
12     eta_o=62/100;   //Overall Efficiency
13
14
15 //Data Used:–
16     rho=1000;       //Density of Water, kg/m^3
17     g=9.81;         //Acceleration due to gravity,
18                     m/s^2
19
20 //Computations:–
21     Q=Q/1000;       //m^3/s
22
23     P=rho*Q*g*H/(eta_o*1000); //kW
24
25 //Result:–
26     printf("The Power of the Pump, P=%0.3 f kW \n"
27            ,P)

```

Scilab code Exa 11.4 To Find a Vane Angle at Inlet b Work done by Impeller on water

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.4
4 //To Find (a)Vane Angle at Inlet (b)Work

```



```

done by Impeller on water per second          (c)
Manometric Efficiency

5
6     clc
7     clear
8
9 //Given Data:-
10    //As Outer Diameter equals two times Inner
    Diameter ,
11    Do_by_Di=2;           //Do/Di
12    N=980;                //Speed, rpm
13    Hm=52;                //Manometric Head, m
14    Vfo=2.6;              //Velocity of Flow, m/s
15    Vfi=Vfo;
16    beta_o=42;           //Vane Angle at outlet,
    degrees
17    Do=600;               //Outer Diameter of the
    Impeller, mm
18    bo=60;                //Width at Outlet, mm
19
20
21 //Data Used:-
22    rho=1000;             //Density of water, kg/
    m^3
23    g=9.81;               //Acceleration due to
    gravity, m/s^2
24
25 //Computations:-
26    Do=Do/1000;           //m
27    bo=bo/1000;           //m
28
29    Di=Do/Do_by_Di;       //Diameter at
    Inlet of Impeller, m
30    ui=%pi*Di*N/60;      //Tangential
    velocity of Impeller at Inlet, m/s
31    uo=%pi*Do*N/60;      //Tangential
    velocity of Impeller at Outlet, m/s
32    Q=%pi*Do*bo*Vfo;     //Discharge, m^3/s

```

```

33
34 // (a) Vane Angle at Inlet , beta_i
35     beta_i=atand(Vfi/ui);           //degrees
36
37 // (b) Work done by Impeller on water per sec , W
38     Vwo=uo-Vfo/tand(beta_o);       //m/s
39     W=rho*Q*Vwo*uo/1000;          //kN-m/s
40
41 // (c) Manometric Efficiency , eta_man
42     eta_man=g*Hm/(Vwo*uo)*100;     //In
43                                     Percentage
44
45 // Results:-
46     printf(" (a) Vane Angle at Inlet , beta_i=%0.2f
47           Degrees \n ",beta_i)
48     printf(" (b) Work done by Impeller on water
49           per sec =%0.3f kN-m/s \n ",W) //The
50           answer provided in the textbook is wrong.
51     printf(" (c) Manometric Efficiency , eta_man =%0
52           .2f Percent \n ",eta_man) //The answer
53           provided in the textbook is wrong.

```

Scilab code Exa 11.5 To Find the Discharge of Pump

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.5
4 //To Find the Discharge of Pump.
5
6     clc
7     clear
8
9 //Given Data:-
10     Hm=14.5;           //Manometric Head, m

```

```

11         N=1000;           //Speed, rpm
12         beta_o=30;       //Vane Angle at outlet,
                        degrees
13         Do=300;         //Outer Diameter of the
                        Impeller, mm
14         bo=50;          //Width at Outlet, mm
15         eta_man=95/100;  //Manometric
                        Efficiency
16
17
18 //Data Used:-
19         g=9.81;         //Acceleration due to
                        gravity, m/s^2
20
21 //Computations:-
22         Do=Do/1000;     //m
23         bo=bo/1000;     //m
24
25         uo=%pi*Do*N/60; //m/s
26         Vwo=g*Hm/(uo*eta_man); //m/s
27         Vfo=tand(beta_o)*(uo-Vwo); //m/s
28         Q=%pi*Do*bo*Vfo*1000; //Discharge,
                        litres/s
29
30 //Results:-
31         printf("The Discharge of the Pump=%.2f litres
/s\n",Q) //The answer vary due to
round off error

```

Scilab code Exa 11.6 To Calculate the Blade angle at Outlet Power Required and Over

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.6
4 //To Calculate the Blade angle at Outlet, Power

```

Required and Overall Efficiency of Pump.

```
5
6     clc
7     clear
8
9 //Given Data:-
10     Do=80;           //Outer Diameter of the
11                     Impeller , cm
12     Q=1;             //Discharge , m3/s
13     H=80;            //Head, m
14     N=1000;          //Speed, rpm
15     bo=8;            //Width at Outlet, cm
16     Delta_Q_per=3;   //Percentage of Leakage
17                     Loss(of the Discharge)
18     Delta_P=10;      //Mechanical Loss, kW
19     eta_H=80/100;    //Hydraulic Efficiency
20
21 //Data Used:-
22     rho=1000;        //Density of water, kg/m3
23     g=9.81;          //Acceleration due to
24                     gravity , m/s2
25
26 //Computations:-
27     Do=Do/100;       //m
28     bo=bo/100;       //m
29
30     uo=%pi*Do*N/60;   //m/s
31     Vfo=Q/(%pi*Do*bo); //m/s
32     Vwo=g*H/(uo*eta_H); //m/s
33     Vrwo=uo-Vwo;     //m/s
34
35 // (a)
36     beta_o=atand(Vfo/Vrwo); //Blade
37                     Angle at Outlet, degrees
38
39 //Result1
40     printf(" Blade Angle at Outlet , beta_o=%
```

```

        .2f Degrees \n",beta_o) //The
        answer vary due to round off error
38
39 // (b) Power Required
40 Pi=rho*(1+Delta_Q_per/100)*Q*Vwo*uo;
        //Power delivered by the
        Impeller , W
41 P=Pi/1000+Delta_P; //Power required
        , kW
42
43 //Result2
44 printf(" Power Required , P =%.3f kW \n",
        P) //The answer vary due to round
        off error
45
46 // (c) Overall Efficiency , eta_o
47 eta_V=1/(1+Delta_Q_per/100); //
        Volumetric Efficiency
48 eta_m=(P-Delta_P)/P; //Mechanical
        Efficiency
49 eta_o=eta_H*eta_V*eta_m*100; //In
        Percentage
50
51 //Result3
52 printf(" Overall Efficiency , eta_o =%.2f
        Percent \n",eta_o) //The answer
        vary due to round off error
53
54 //Also, Overall Efficiency
55 eta_o=rho*Q*g*H/(P*1000)*100; //In
        Percentage
56
57 printf(" Also , Overall Efficiency , eta_o=%.2f
        Percent\n",eta_o)

```

Scilab code Exa 11.7 To Determine the Impeller Speed and Torque produced by it

```
1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.7
4 //To Determine the Impeller Speed and Torque
   produced by it .
5
6     clc
7     clear
8
9 //Given Data:–
10     Q=60;           //Discharge , litres/s
11     Ri=75;         //Radius  of the Impeller at
       Inlet , mm
12     Ro=150;        //Radius of the Impeller at
       Outlet , cm
13     beta_o=30;     //Vane Angle at Outlet ,
       degrees
14     beta_i=30;     //Vane Angle at Inlet ,
       degrees
15     Ai=0.025;      //Impeller Area at Inlet , m
       ^2
16
17
18 //Data Used:–
19     rho=1000;      //Density of water , kg/m^3
20
21
22 //Computations:–
23     Q=Q/1000;      //m^3/s
24     Ri=Ri/1000;    //m
25     Ro=Ro/1000;    //m
26
27     Di=2*Ri;       //m
28     Do=2*Ro;       //m
29     Vfi=Q/Ai;      //m/s
30     Vfo=Vfi;
```

```

31         ui=Vfi/tand(beta_i);           //m/s
32         N=ui*60/(%pi*Di);             //rpm
33
34         uo=%pi*Do*N/60;               //m/s
35         Vrwo=Vfo/tand(beta_o);        //m/s
36         Vwo=uo-Vrwo;                  //m/s
37         P=rho*Q*Vwo*uo;               //Impeller Power, W
38         Ti=P*60/(2*%pi*N);           //Impeller Torque,
                                     N-m
39
40 //Results:-
41         printf(" Impeller Speed , N=%0.2 f rpm\n",N)
                                     //The answer vary due to round off
                                     error
42         printf(" Impeller Torque , Ti=%0.2 f N-m\n",Ti)
                                     //The answer vary due to round off
                                     error

```

Scilab code Exa 11.8 To Determine the Power Required to drive the centrifugal Pump

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.8
4 //To Determine the Power Required to drive the
   centrifugal Pump.
5
6     clc
7     clear
8
9 //Given Data:-
10        Q=40;           //Discharge , litres/s
11        Hst=20;        //Static Head, m
12        D=150;        //Diameter of Pipe, mm
13        L=100;        //length of pipe, m
14        eta_o=70/100; //Overall Efficiency

```

```

15         f=0.015;           //Coefficient of friction
16
17
18 //Data Used:-
19         rho=1000;          //Density of water , kg/m^3
20         g=9.81;           //Acceleration due to gravity
                , m/s^2
21
22
23 //Computations:-
24         Q=Q/1000;         //m^3/s
25         D=D/1000;         //m
26
27         A=(%pi/4)*D^2;     //m^2
28         V=Q/A;             //m/s
29         Vd=V;
30
31         h_f=4*f*L*V^2/(2*g*D);           //
                Frictional Head Loss in Pipe , m
32         Hm=Hst+h_f+Vd^2/(2*g);         //Manometric
                Head, m
33         P=rho*Q*g*Hm/(eta_o*1000);     //kW
34
35 //Result:-
36         printf("Power Required to drive the
                Centrifugal Pump=%.3f kW\n",P) //The
                answer vary due to round off error

```

Scilab code Exa 11.9 To Find i Vane Angle at Inlet ii Work done by Impeller on water

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.9
4 //To Find (i)Vane Angle at Inlet (ii)Work
    done by Impeller on water per second and (

```


iii) Manometric Efficiency .

```
5
6     clc
7     clear
8
9 //Given Data:-
10     Do=500;           //Outer Diameter of the
                        Impeller , mm
11     Di=250;          //Inner Diameter of the
                        Impeller , mm
12     N=1000;          //Speed, rpm
13     Hm=40;           //Manometric Head, m
14     Vfo=2.5;         //Velocity of Flow, m/s
15     Vfi=Vfo;
16     beta_o=40;       //Vane Angle at outlet ,
                        degrees
17     bo=50;           //Width at Outlet , mm
18
19
20 //Data Used:-
21     rho=1000;        //Density of water , kg/
                        m^3
22     g=9.81;          //Acceleration due to
                        gravity , m/s^2
23
24 //Computations:-
25     Do=Do/1000;      //m
26     Di=Di/1000;      //m
27     bo=bo/1000;      //m
28
29     ui=%pi*Di*N/60;   //Tangential
                        velocity of Impeller at Inlet ,m/s
30     uo=%pi*Do*N/60;   // Tangential
                        velocity of Impeller at Outlet , m/s
31     Q=%pi*Do*bo*Vfo; //Discharge , m^3/s
32
33 // (i) Vane Angle at Inlet , beta_i
34     beta_i=atand(Vfi/ui); //degrees
```

```

35
36 // (ii) Work done by Impeller on water per sec , W
37     Vwo=uo-Vfo/tand(beta_o); //m/s
38     W=rho*Q*Vwo*uo/1000; //kN-m/s
39
40 // (iii) Manometric Efficiency , eta_man
41     eta_man=g*Hm/(Vwo*uo)*100; //In
         Percentage
42
43
44 //Results:-
45     printf(" (i)Vane Angle at Inlet , beta_i=%0.2f
         Degrees \n ",beta_i) //The answer vary
         due to round off error
46     printf(" (ii) Work done by Impeller on water
         per sec =%0.3f kN-m/s \n ",W) //The
         answer vary due to round off error
47     printf(" (iii) Manometric Efficiency , eta_man
         =%0.2f Percent \n ",eta_man) //The
         answer vary due to round off error

```

Scilab code Exa 11.10 To Find i Manometric Head ii Manometric Efficiency iii Overall

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.10
4 //To Find (i)Manometric Head (ii)
         Manometric Efficiency (iii)Overall
         Efficiency of the Pump.
5
6     clc
7     clear
8
9 //Given Data:-
10     Do=480; //External Diameter of the

```

```

    Impeller , mm
11      Di=240;           //Internal Diameter of the
    Impeller , mm
12      N=1000;          //Speed, rpm
13      Q=0.0576;        //Rate of Flow, m^3/s
14      Vfo=2.4;         //Velocity of Flow, m/s
15      Vfi=Vfo;
16      Ds=180;          //Diameter of Suction Pipe,
    mm
17      Dd=120;          //Diameter of Delivery Pipe,
    mm
18      h_s=6.2;         //Suction Head, m of water (
    abs)
19      h_d=30.2;        //Delivery Head, m of water
    (abs)
20      P=35;            //Power required to drive
    the pump, kW
21      beta_o=45;       //Vane Angle at outlet,
    degrees
22
23
24 //Data Used:-
25      rho=1000;        //Density of water, kg/
    m^3
26      g=9.81;         //Acceleration due to
    gravity, m/s^2
27
28 //Computations:-
29      Do=Do/1000;      //m
30      Di=Di/1000;      //m
31      Ds=Ds/1000;      //m
32      Dd=Dd/1000;      //m
33      P=P*1000;        //W
34
35      //(i) Manometric Head, Hm
36
37      As=(%pi/4)*Ds^2; //m^2
38      Ad=(%pi/4)*Dd^2; //m^2

```

```

39         Vd=Q/Ad;           //m/s
40         Vs=Q/As;           //m/s
41         Hm=(h_d+Vd^2/(2*g))-(h_s+Vs^2/(2*g));
           //m
42
43
44         uo=%pi*Do*N/60;     // Tangential
           velocity of Impeller at Outlet, m/s
45         Vwo=uo-Vfo/tand(beta_o); //m/s
46
47         //(ii) Manometric Efficiency, eta_man
48         eta_man=g*Hm/(Vwo*uo)*100; //In
           Percentage
49
50         //(iii) The Overall Efficiency of the Pump,
           eta_o
51         eta_o=rho*Q*g*Hm/P*100; //In
           percentage
52
53 //Results:-
54         printf(" (i) Manometric Head, Hm =%.2 f m \n ",
           Hm)
55         printf(" (ii) Manometric Efficiency, eta_man =
           %.2 f Percent \n ",eta_man) //The answer
           vary due to round off error
56         printf(" (iii) The Overall Efficiency of the
           Pump, eta_o =%.2 f Percent \n ",eta_o)
           //The answer vary due to round off error

```

Scilab code Exa 11.11 To Find Vane Angle at Outer periphery of Impeller

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.11
4 //To Find Vane Angle at Outer periphery of Impeller

```

```

5
6     clc
7     clear
8
9 //Given Data:-
10     Q=0.118;           //discharge , m^3/s
11     N=1450;           //Speed , rpm
12     Hm=25;            //Manometric Head, m
13     Do=250;           //Diameter of the Impeller
                        at Outlet , mm
14     bo=50;            //Width at Outlet , mm
15     eta_man=75/100;    //Manometric
                        Efficiency
16
17
18 //Data Used:-
19     g=9.81;           //Acceleration due to
                        gravity , m/s^2
20
21 //Computations:-
22     Do=Do/1000;       //m
23     bo=bo/1000;       //m
24
25     uo=%pi*Do*N/60;    // Tangential
                        velocity of Impeller at Outlet , m/s
26     Vwo=g*Hm/(uo*eta_man); //m/s
27     Vfo=Q/(%pi*Do*bo); //m/s
28     beta_o=atand(Vfo/(uo-Vwo)); //
                        degrees
29
30 //Results:-
31     printf(" Vane Angle at Outlet , beta_o=%0.2f
                        Degrees \n ",beta_o) //The answer vary
                        due to round off error

```

Scilab code Exa 11.12 To Determine i Manometric Efficiency ii Vane Angle at Inlet

```
1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.12
4 //To Determine (i)Manometric Efficiency
                    (ii)Vane Angle at Inlet (iii)The
                    Least Speed at which the pump commence to work.
5
6     clc
7     clear
8
9 //Given Data:–
10     Do=0.5;           //Outer Diameter of the
                        Impeller , m
11     N=600;           //Speed , rpm
12     Q=8000;          //Discharge , litres/min.
13     Hm=8.5;          //Manometric Head, m
14     Di=0.25;         //Inner Diameter of
                        Impeller , m
15     beta_o=45;       //Vane Angle at outlet ,
                        degrees
16     Af=0.06;         //Area of Flow , m2
17
18
19 //Data Used:–
20     g=9.81;          //Acceleration due to
                        gravity , m/s2
21
22 //Computations:–
23     Q=Q/60000;       //m3/s
24
25     Vfo=Q/Af;        //m/s
26     Vfi=Vfo;
```

```

27     ui=%pi*Di*N/60;           //Tangential velocity
      of Impeller at Inlet ,m/s
28     uo=%pi*Do*N/60;         // Tangential velocity
      of Impeller at Outlet , m/s
29     Vwo=uo-Vfo/tand(beta_o); //m/s
30
31     //(i) Manometric Efficiency , eta_man
32     eta_man=g*Hm/(Vwo*uo)*100; //In
      Percentage
33
34
35     //(ii) Vane Angle at Inlet , beta_i
36     beta_i=atand(Vfi/ui);    //degrees
37
38     //(iii) The Least Speed at which the pump
      commence to work , Nmin
39     Nmin=120*Vwo*Do*(eta_man/100)/(%pi*(Do^2-Di
      ^2)); //rpm
40
41
42
43 //Results:-
44     printf(" (i) Manometric Efficiency , eta_man =%
      .2f Percent \n ",eta_man ) //The answer
      vary due to round off error
45     printf(" (ii) Vane Angle at Inlet , beta_i=%
      .2f Degrees \n ",beta_i ) //The answer
      vary due to round off error
46     printf(" (iii) The Least Speed at which the
      pump commence to work , Nmin=%
      .2f rpm \n",
      Nmin ) //The answer vary due to round
      off error

```

Scilab code Exa 11.13 To Find i The Discharge of the Pump ii The Pressure at Sucti

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.13
4 //To Find          (i)The Discharge of the Pump
                    (ii)The Pressure at Suction and Delivery
                        side of the Pump.
5
6         clc
7         clear
8
9 //Given Data:–
10        h_st=35;           //Static Head, m
11        h_s=4;            //Suction Head, m
12        D=150;            //Diameter of Pipes, mm
13        Ds=D;            //Diameter of Suction Pipe, mm
14        Dd=D;            //Diameter of Delivery Pipe,
                            mm
15        h_fs=1.6;         //Head loss in Suction pipe,
                            m
16        h_fd=6.5;         //Head loss in Delivery Pipe,
                            m
17        Do=380;           //Diameter of Impeller at
                            Outlet, mm
18        bo=25;           //Width of Impeller at Outlet
                            , mm
19        N=1200;           //Speed, rpm
20        beta_o=35;        //Exit Blade Angle,
                            degrees
21        eta_man=80/100;   //Manometric
                            Efficiency
22
23
24 //Data Used:–
25        g=9.81;           //Acceleration due to
                            gravity, m/s^2
26
27 //Computations:–
28        Do=Do/1000;       //m

```



```

29         D=D/1000;           //m
30         Ds=Ds/1000;        //m
31         Dd=Dd/1000;        //m
32         bo=bo/1000;        //m
33
34         Hm=h_st+h_fs+h_fd;   // Manometric Head,
           m
35         uo=%pi*Do*N/60;     // Tangential
           velocity of Impeller at Outlet , m/s
36         Vwo=g*Hm/(uo*eta_man); //m/s
37         Vfo=(uo-Vwo)*tand(beta_o); //m/s
38
39         //(i)The Discharge of the Pump, Q
40         Q=%pi*Do*bo*Vfo*1000; //litres/s
41
42         //(ii)The Pressure at Suction and Delivery side
           of the Pump
43
44         A=(%pi/4)*D^2;      //m^2
45         Vd=Q*10^-3/A;      //m/s
46         Vs=Vd;             //m/s
47         Hs=h_s+h_fs+Vs^2/(2*g); //Pressure
           on Suction Side, m of water
48         h_d=h_st-h_s;      //m
49         Hd=h_d+h_fd+Vd^2/(2*g); //Pressure
           on Delivery Side, m of water
50
51
52 //Result:-
53     printf(" (i)The Discharge of the Pump, Q =%.2 f
           litres/s\n",Q) //The answer vary due to
           round off error
54     printf(" (ii) Pressure on Suction Side , Hs =%.
           3 f m of water \n",Hs) //The answer vary
           due to round off error
55     printf("          Pressure on Delivery Side , Hd =%.
           2 f m of water \n",Hd) //The answer vary
           due to round off error

```

Scilab code Exa 11.14 To Find a Vane Angle of Impeller at Inlet b Overall Efficiency

```
1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.14
4 //To Find      (a)Vane Angle of Impeller at Inlet
                  (b) Overall Efficiency of the Pump
                  (c) Manometric Efficiency of the Pump.
5
6     clc
7     clear
8
9 //Given Data:–
10     Do=400;           //Diameter of the Impeller
                       at Outlet , mm
11     Di=200;           //Diameter of the Impeller
                       at Inlet , mm
12     N=1000;           //Speed , rpm
13     Q=39;             //Discharge , litres/s
14     Vfo=2.2;          //Velocity of Flow , m/s
15     Vfi=Vfo;
16     Ds=150;           //Diameter of Suction Pipe ,
                       mm
17     Dd=100;           //Diameter of Delivery Pipe ,
                       mm
18     h_s=6;            //Suction Head, m of water (
                       abs)
19     h_d=30;           //Delivery Head, m of water (
                       abs)
20     P=15.75;          //Power required to drive
                       the pump, kW
21     beta_o=45;        //Vane Angle at outlet ,
                       degrees
22
```

```

23
24 //Data Used:-
25     rho=1000;           //Density of water , kg/
                          m^3
26     g=9.81;           //Acceleration due to
                          gravity , m/s^2
27
28 //Computations:-
29     Do=Do/1000;       //m
30     Di=Di/1000;       //m
31     Ds=Ds/1000;       //m
32     Dd=Dd/1000;       //m
33     Q=Q/1000;         //m^3/s
34     P=P*1000;         //W
35
36     //(a)Vane Angle of Impeller at Inlet , beta_i
37     ui=%pi*Di*N/60;    //m/s
38     beta_i=atand(Vfi/ui); //degrees
39
40     //(b) Overall Efficiency of the Pump
41     As=(%pi/4)*Ds^2;   //m^2
42     Ad=(%pi/4)*Dd^2;   //m^2
43     Vd=Q/Ad;           //m/s
44     Vs=Q/As;           //m/s
45     Hm=(h_d+Vd^2/(2*g))-(h_s+Vs^2/(2*g));
                          //m
46     eta_o=rho*Q*g*Hm/P*100; //In percentage
47
48
49     //(c) Manometric Efficiency of the Pump,
    eta_man
50     uo=%pi*Do*N/60;    // Tangential
                          velocity of Impeller at Outlet , m/s
51     Vwo=uo-Vfo/tand(beta_o); //m/s
52     eta_man=g*Hm/(Vwo*uo)*100; //In
                          Percentage
53
54

```

```

55 //Results:-
56     printf(" (a)Vane Angle of Impeller at Inlet ,
           beta_i=%0.2f Degrees \n ",beta_i) //The
           answer vary due to round off error
57     printf(" (b) The Overall Efficiency of the
           Pump, eta_o =%0.2f Percent \n ",eta_o) //
           The answer vary due to round off error
58     printf(" (c) Manometric Efficiency of the Pump
           , eta_man =%0.2f Percent \n ",eta_man) //
           The answer vary due to round off error

```

Scilab code Exa 11.15 To Determine Minimum Starting Speed of the Pump

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.15
4 //To Determine Minimum Starting Speed of the Pump.
5
6     clc
7     clear
8
9 //Given Data:-
10     Di=300;           //Diameter of Impeller at
                       Inlet , mm
11     Do=600;           //Diameter of the Impeller
                       at Outlet , mm
12     Vfo=2.6;          //Velocity of Flow at Outlet
                       , m/s
13     beta_o=42;        //Vane Angle at outlet ,
                       degrees
14     eta_man=65/100;    //Manometric
                       Efficiency , m^2
15
16
17 //Computations:-

```

```

18     Di=Di/1000;           //m
19     Do=Do/1000;         //m
20
21     uo_by_N=%pi*Do/60;   // uo/N
22
23     //Minimum Starting Speed of The Centrifugal
24     Pump, Nmin
25     Nmin=(120*Do*eta_man*Vfo/(tand(beta_o)*%pi
26           *(Do^2-Di^2)))/(120*eta_man*Do*uo_by_N/(
27           %pi*(Do^2-Di^2))-1); //rpm
28
29 //Results:-
30     printf("The Minimum Starting Speed of the
31           Centrifugal Pump, Nmin =%.2f rpm \n",Nmin )
32           //The answer vary due to round off error

```

Scilab code Exa 11.16 To Determine Minimum Starting Speed of the Pump

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.16
4 //To Determine Minimum Starting Speed of the Pump.
5
6     clc
7     clear
8
9 //Given Data:-
10     Di=200;           //Diameter of Impeller at
11                       Inlet , mm
12     Do=400;           //Diameter of the Impeller
13                       at Outlet , mm
14     Hm=25;           //Manometric Head, m

```

```

14 //Data Used:-
15     g=9.81;           // Acceleration due to gravity
16     , m/s^2
17
18 //Computations:-
19     Di=Di/1000;      //m
20     Do=Do/1000;      //m
21
22     uo_by_Nmin=%pi*Do/60;    // uo/Nmin
23     ui_by_Nmin=%pi*Di/60;    // ui/Nmin
24
25     //Minimum Starting Speed of The Centrifugal
26     Pump, Nmin
27     Nmin=sqrt(2*g*Hm/(uo_by_Nmin^2-ui_by_Nmin
28     ^2));           //rpm
29
30 //Results:-
31     printf("The Minimum Starting Speed of the
32     Centrifugal Pump, Nmin =%.f rpm \n",Nmin )
33     //The answer vary due to round off error

```

Scilab code Exa 11.17 To Find a Manometric Efficiency b Minimum Starting Speed

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.17
4 //To Find (a)Manometric Efficiency. (b
5 )Minimum Starting Speed
6
7     clc
8     clear

```

```

9 //Given Data:-
10     Di=1200;           //Inner Diameter of the
        Impeller , mm
11     Do=600;           //Outer Diameter of the
        Impeller , mm
12     N=200;            //Speed , rpm
13     Hm=6;             //Manometric Head , m
14     beta_o=26;        // Vane Angle at Outlet ,
        degrees
15     Vfo=2.5;         // Velocity of flow at Outlet ,
        m/s
16
17
18 //Data Used : -
19     g=9.81;           //Acceleration due to gravity ,
        m/s^2
20
21
22 //Computations:-
23     Di=Di/1000;       //m
24     Do=Do/1000;       //m
25
26     uo=%pi*Di*N/60;   //Tangential
        Velocity of Impeller at Outlet , m/s
27     Vwo=uo-Vfo/tand(beta_o); //m/s
28
29     //(a)Manometric Efficiency , eta_man
30     eta_man=g*Hm/(Vwo*uo)*100; //
        In Percentage
31
32     //(b) Minimum Starting Speed , Nmin
33     Nmin =sqrt(2*g*Hm*60^2/(%pi^2*(
        Di^2-Do^2))); //rpm
34
35
36 //Results:-
37     printf("(a)Manometric Efficiency =%.2f
        Percent \n",eta_man) //The answer

```

```

38          vary due to round off error
          printf(" (b)Minimum Starting Speed , Nmin
              =%.f rpm",Nmin) //The answer vary
              due to round off error

```

Scilab code Exa 11.18 To Find a Manometric Efficiency b Inlet Vane Angles c Loss of Head

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.18
4 //To Find      (a)Manometric Efficiency.      (b
    )Inlet Vane Angles.      (c)Loss of Head at
    Inlet of Impeller
5
6      clc
7      clear
8
9 //Given Data:-
10     Q=0.21;           //Discharge , m^3/s
11     Af=0.085;       //Cross-sectional Area of Flow
                       , m^2
12     Di=300;         //Inner Diameter of the
                       Impeller , mm
13     Do=600;         //Outer Diameter of the
                       Impeller , mm
14     N=600;          //Speed , rpm
15     Hm=19;          //Manometric Head, m
16     beta_o=35;      //degrees
17     Q_per=30;       //Percentage by which
                       Discharge is reduced
18
19
20 //Data Used: –
21     g=9.81;         //Acceleration due to gravity ,
                       m/s^2

```



```

22
23
24 //Computations:-
25         Di=Di/1000;           //m
26         Do=Do/1000;           //m
27
28         ui=%pi*Di*N/60;        //Tangential
           Velocity of Impeller at Inlet, m/s
29         uo=%pi*Do*N/60;        //Tangential
           Velocity of Impeller at Outlet, m/s
30         Vfo=Q/Af;             //Velocity of Flow, m
           /s
31         Vfi= Vfo;
32         Vwo=uo-Vfo/tand(beta_o); //m/s
33
34         //(a)Manometric Efficiency, eta_man
35         eta_man=g*Hm/(Vwo*uo)*100; //In
           Percentage
36
37         //(b)Inlet Vane Angle, beta_i
38         beta_i=atand(Vfi/ui); //degrees
39
40         //(c)Loss of Head at inlet, H_L
41         Q_dash=Q-Q_per/100*Q; //m^3/s
42         Vfi_dash=Q_dash/Af; //m/s
43         H_L=(ui-Vfi_dash*cotd(beta_i) )^2/(2*g
           ); // m of water
44
45 //Results
46     printf("(a)Manometric Efficiency, eta_man =%.2f
           Percent \n",eta_man) //The answer vary
           due to round off error
47     printf ("(b)Inlet Vane Angle, beta_i =%.2f
           Degrees \n",beta_i) //The answer vary
           due to round off error
48     printf ("(c)Loss of Head at Inlet to the
           Impeller =%.3f m of water", H_L) //The
           answer vary due to round off error

```

Scilab code Exa 11.19 To Find a Head generated and b Power consumed

```
1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.19
4 //To Find (a)Head generated and (b)
   Power consumed
5
6     clc
7     clear
8
9 //Given Data:–
10    n=2;           //Number of Stages
11    Q=100;        //Discharge , litres/s
12    N=1000;      //Speed , rpm
13    Do=500;      //Diameter of the Impeller
   at Outlet , mm
14    bo=25;       //Width of Impeller at outlet
   , mm
15    beta_o=30;   //degrees
16    Area_per=10; //Percentage of Total
   Area which is covered due to blade
   thickness
17    eta_o=78/100; //Overall Efficiency
18    eta_man=85/100; //Manometric
   Efficiency
19
20
21 //Data Used: –
22    rho=1000;    //Density of water
   , kg/m^3
23    g=9.81;     //Acceleration due to gravity
   , m/s^2
24
```

```

25
26 // Computations:-
27     Q=Q/1000;           //m^3/s
28     Do=Do/1000;        //m
29     bo=bo/1000;        //m
30     A=%pi*Do*bo*(1-Area_per/100); //
        Actual Area of Flow, m^2
31
32     uo=%pi*Do*N/60;     //Tangential
        Velocity of Impeller at Outlet, m/s
33     Vfo=Q/A;           //Velocity of Flow, m/
        s
34     Vfi= Vfo;
35     Vwo=uo-Vfo/tand(beta_o); //m/s
36
37     //(a) Head generated, H_Tm
38     Hm=eta_man*Vwo*uo/g; //m
39     H_Tm=n*Hm;         //m
40
41     //(b) Power consumed, P
42     P=rho*Q*g*H_Tm/(eta_o*1000); //kW
43
44
45 // Results:-
46     printf(" (a) Head Generated, H_Tm=%0.2 f m \n"
        ,H_Tm) //The answer vary due to round
        off error
47     printf(" (b) Power consumed, P =%0.2 f kW \n"
        ,P) //The answer vary due to round off
        error

```

Scilab code Exa 11.20 To Determine i Head generated by the Pump ii Shaft Power req

1 // Fluid Systems – By – Shiv Kumar

```

2 //Chapter 11– Centrifugal Pumps
3 //Example 11.20
4 //To Determine      (i)Head generated by the Pump
                    (ii)Shaft Power required to run the Pump
5
6         clc
7         clear
8
9 //Given Data:–
10      n=3;           //Number of Stages
11      Do=400;       //Diameter of the Impeller
                    at Outlet , mm
12      bo=20;        //Width of Impeller at outlet
                    , mm
13      beta_o=45;    //degrees
14      Area_per=10;  //Percentage of Total
                    Area which is reduced.
15      eta_o=80/100; //Overall Efficiency
16      eta_man=90/100; //Manometric
                    Efficiency
17      N=1000;       //Speed , rpm
18      Q=0.05;       //Discharge , m^3/s
19
20
21 //Data Used: –
22      rho=1000;     //Density of water
                    , kg/m^3
23      g=9.81;      //Acceleration due to gravity
                    , m/s^2
24
25
26 //Computations:–
27      Do=Do/1000;  //m
28      bo=bo/1000;  //m
29      A=%pi*Do*bo*(1-Area_per/100); //
                    Actual Area of Flow , m^2
30

```

```

31         uo=%pi*Do*N/60;           //Tangential
           Velocity of Impeller at Outlet, m/s
32         Vfo=Q/A;           //Velocity of Flow, m/
           s
33         Vfi= Vfo;
34         Vwo=uo-Vfo/tand(beta_o);   //m/s (
           Value given in book is wrong due to
           incorrect value of beta_o is used)
35
36         // (i)Head generated by the Pump , H_Tm
37         Hm=eta_man*Vwo*uo/g;       //m
38         H_Tm=n*Hm;               //m
39
40         //((ii) Shaft Power required to run the Pump ,
           P
41         P=rho*Q*g*H_Tm/(eta_o*1000);
           //kW
42
43
44 //Results:-
45         printf(" (i)Head generated by the Pump ,
           H_Tm=%0.2 f m \n",H_Tm) //The answer
           provided in the textbook is wrong
46         printf(" (ii) Shaft Power required to run
           the Pump , P =%0.2 f kW \n",P) //The
           answer provided in the textbook is
           wrong

```

Scilab code Exa 11.21 To Find the Manometric Efficiency

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11– Centrifugal Pumps
3 //Example 11.21
4 //To Find the Manometric Efficiency
5         clc

```

```

6         clear
7
8 //Given Data:-
9         n=4;                //Number of Pumps
10        N=400;              //Speed, rpm
11        H_Tm=40;            //Total Manometric Head, m
12        Q=0.2;              //Discharge, m^3/s
13        beta_o=40;          //Vane Angle at Outlet,
           degrees
14        Do=600;              //Diameter of the Impeller
           at Outlet, mm
15        bo=50;              //Width of Impeller at outlet
           , mm
16
17
18 //Data Used: -
19        rho=1000;            //Density of water
           , kg/m^3
20        g=9.81;             //Acceleration due to gravity
           , m/s^2
21
22
23 //Computations:-
24        Do=Do/1000;          //m
25        bo=bo/1000;          //m
26        A=%pi*Do*bo;         //Area of Flow, m^2
27        Hm=H_Tm/n;           //Manometric Head
           of each Pump, m
28
29        uo=%pi*Do*N/60;       //Tangential
           Velocity of Impeller at Outlet, m/s
30        Vfo=Q/A;             //Velocity of Flow, m/
           s
31        Vfi= Vfo;
32        Vwo=uo-Vfo/tand(beta_o); //m/s
33
34        eta_man=g*Hm/(Vwo*uo)*100; //
           Manometric Efficiency in Percentage

```

```

35
36
37 //Results:-
38     printf(" Manometric Efficiency , eta_man=%%.2
           f Percent \n",eta_man)           //The
           answer vary due to round off error

```

Scilab code Exa 11.22 To Find a Working Speed of the Prototype b Shaft Power of the

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11 – Centrifugal Pumps
3 //Example 11.22
4
5     clc
6     clear
7
8 //Given Data:-
9     //For Model ,
10        H_mM=7.5;           //Manometric Head, m
11        Nm=1000;           //Speed , rpm
12        Pm=25;             //Shaft Power , kW
13
14        //For Prototype ,
15        H_mP=23;           //Manometric Head, m
16
17        Dm_by_Dp=1/6;     //Scale Ratio
18
19
20 //Computations:-
21
22        // (a)Working Speed of the Prototype , Np
23        Np=Nm*Dm_by_Dp*sqrt(H_mP/H_mM); //
           rpm
24
25        // (b)Shaft Power of the Prototype , Pp

```

```

26             Pp=Pm*(Np/Nm)^3*(1/Dm_by_Dp)^5;
                //kW
27
28         // (c)Ratio of Flow Rates handled by the
        prototyptpe and the Model, Qp/Qm
29         Qp_by_Qm=(Np/Nm)*(1/Dm_by_Dp)^3;
30
31 // Results:-
32     printf(" (a)Working Speed of the Prototype
        , Np =%.2f rpm\n",Np)           //The
        answer vary due to round off error
33     printf(" (b)Shaft Power of the Prototype ,
        Pp =%.2f kW\n",Pp)           //The answer
        vary due to round off error
34     printf(" (c)Ratio of Flow Rates handled by
        the prototyptpe and the Model=%.2f ",
        Qp_by_Qm)           //The answer provided
        in the textbook is wrong

```

Scilab code Exa 11.23 To Find the Head and Impeller Diameter of the other Pump

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11 – Centrifugal Pumps
3 //Example 11.23
4 //To Find the Head and Impeller Diameter of the
        other Pump.
5
6     clc
7     clear
8
9 //Given Data:-
10         //For Pump-1,
11         N1=1000;           //Speed , rpm
12         D1=320;           //Impeller Diameter ,
                            mm

```



```

13             Hm1=16;           //Manometric Head, m
14             Q1=0.021;        //Discharge , m^3/s
15
16             //For Pump-2,
17             N2=1000;          //Speed , rpm
18             //As other Pump has to deliver half the
             discharge ,
19             Q2=Q1/2;         //m^3/s
20
21
22 // Computations:-
23             Hm2=Hm1*(N2/N1)*sqrt(Q2/Q1);           //
             m
24             D2=D1*(N1/N2)*sqrt(Hm2/Hm1);           //
             mm
25
26 // Results:-
27             printf("Head of the other Pump(Pump-2), Hm2=%
             .2 f m\n",Hm2)
28             printf("Impeller Diameter of the other Pump(
             Pump-2), D2=%0.2 f mm\n",D2)           //The
             answer vary due to round off error

```

Scilab code Exa 11.24 To Find the the number of stages and Diameter of each Impeller

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11 – Centrifugal Pumps
3 //Example 11.24
4 //To Find the the number of stages and Diameter of
   each Impeller of the similar multistage Pump.
5
6     clc
7     clear
8
9 //Given Data:-

```

```

10         //For Single Stage Pump,
11         N1=2000;           //Speed, rpm
12         D1=300;           //Impeller Diameter,
                             mm
13         Hm1=32;           //Manometric Head, m
14         Q1=3;             //Discharge, m^3/s
15
16         //For Multi Stage Pump,
17         N2=1600;           //Speed, rpm
18         H_mT2=200;        //Total Manometric
                             Head, m
19         Q2=5;             //Discharge, m^3/s
20
21
22 //Computations:-
23         Hm2=Hm1*(N2/N1)*sqrt(Q2/Q1);           //
                             m
24         n=round(H_mT2/Hm2);           //No. of
                             stages
25         D2=D1*(N1/N2)*sqrt(Hm2/Hm1);           //
                             Diameter of Each Impeller, mm
26
27 //Results:-
28         printf("Number of the Stages for the Multi
                stage Pump, n=%f \n",n)
29         printf("Diameter of each Impeller for the
                Multi stage Pump, D2=%f mm\n",D2)
                //The answer vary due to round off
                error

```

Scilab code Exa 11.25 To Find the Discharge and Head of the Pump at Condition 2 an

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11 – Centrifugal Pumps
3 //Example 11.25

```

```

4 //To Find the Discharge and Head of the Pump at
   Condition '2' and '3' and Compare the Power
   Consumed in all the cases.
5
6     clc
7     clear
8
9 //Given Data:-
10        //At Condition '1'
11            N1=750;           //Speed , rpm
12            Q1=60;           //Discharge , l/s
13            H1=20;           //Head , m
14
15        //At Condition '2'
16            N2=1200;         //Speed , rpm
17
18        //At Condition '3'
19            N3=4200;         //Speed , rpm
20
21 //Computations:-
22        Q2=Q1*(N2/N1);       // l/s
23        H2=H1*(N2/N1)^2;     //m
24        Q3=Q1*(N3/N1);       // l/s
25        H3=H1*(N3/N1)^2;     //m
26
27 //Results:-
28        printf("At Condition -2 Discharge , Q2=%0.1 f
   l/s and Head , H2=%0.1 f m\n",Q2,H2)
29        printf(" At Condition -3 Discharge , Q3=%0.1 f
   l/s and Head , H3=%0.1 f m\n",Q3,H3)
30        printf(" P1: P2 : P3 = 1 : %0.2 f : %0.2 f ",Q2*
   H2/(Q1*H1),Q3*H3/(Q1*H1)) //The
   answer vary due to round off error

```

Scilab code Exa 11.26 To Calculate the Specific Speed of Pump and the Power Input

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 11 – Centrifugal Pumps
3 //Example 11.26
4 //To Calculate the Specific Speed of Pump and the
   Power Input and Find the Head, Discharge and
   Power required at 900 rpm.
5
6     clc
7     clear
8
9 //Given Data:–
10
11         N=1500;           //Speed , rpm
12         Q=0.2;           //Discharge , m^3/s
13         H=15;            //Head , m
14         eta_o=0.68;      //Overall
                       Efficiency
15         N2=900;         //Speed , rpm
16
17 //Data Used:–
18         rho=1000;       //Density of water , kg/m^3
19         g=9.81;        //Acceleratio due to
                       gravity , m/s^2
20
21
22 //Computations:–
23         Ns=N*Q^(1/2)/(H^(3/4));           // Specific
                       Speed of Pump, SI Units
24         P=rho*g*Q*H /eta_o;             //Power Input
                       , W
25
26         Q1=Q;      H1=H;      N1=N;      P1=P;
27         Q2=Q1*(N2/N1);           // m^3/s
28         H2=H1*(N2/N1)^2;        //m
29         P2=P1*(N2/N1)^3;        //W
30
31 //Results:–
32         printf(" Specific Speed of Pump, Ns=%0.2 f (SI

```

```
Units)\n",Ns)
33 printf(" Power Input , P=%0.2 f W\n",P)
34 printf(" At 900 rpm ( Condition 2)\n\t ")
35 printf(" Head, H2=%0.1 f m \n\t Discharge ,
        Q2=%0.2 f m^3/s,\n\t Power required ,
        P2=%0.2 f W" ,H2 ,Q2 ,P2)
```

Chapter 12

Reciprocating Pumps

Scilab code Exa 12.1 To Determine 1 The Slip 2 The Coefficient of Discharge 3 Theo

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 12– Reciprocating Pumps
3 //Example 12.1
4
5     clc
6     clear
7
8 //Given Data:–
9     Hs_th=4.8;           //Suction Head (
10        Theoretical), m
11     Hd_th=12;          //Delivery Head (
12        Theoretical), m
13     N=90;              //Speed of Pump,
14        rpm
15     D=100;             //Piston Diameter , mm
16     L=150;             //Length of Stroke , mm
17     Q=102;             //Actual Discharge , lit
18        ./min
19     eta_s=60/100;      //Efficiency of
20        Suction Stroke
21     eta_d=75/100;      //Efficiency of
```

Delivery Stroke

```
17
18 //Data Used:-
19     rho=1000;           //Density of Water, kg/m^3
20     g=9.81;           //Acceleration due to
                       gravity , m/s^2
21
22 //Computations:-
23     Vs=(%pi/4)*(D/1000)^2*(L/1000);           //
           Swept volume in one revolution , m^3
24     Vth=Vs*N/60;           //Theoretical
           Volume of Water pumped per second , m^3
25     m=Vth*rho;           //Theoretical Mass Flow
           rate , kg/s
26     m_act=Q*1000/(60*1000);           //Actual mas
           flow rate , kg/s
27
28     Slip=(m-m_act)*100/m;           //Slip in
           Percentage
29     Cd=m_act/m*100;           //Co-efficient of
           Discharge in Percentage
30     Hs=Hs_th/eta_s;           //Suction Head taking
           suction efficiency in account , m
31     Hd=Hd_th/eta_d;           //Delivery Head taking
           delivery efficiency in account , m
32     H=Hs+Hd;           //Total Head, m
33     Pth=m*g*H;           //Theoretical power
           required to Drive the Pump, W
34     A=(%pi/4)*(D/1000)^2;           //Cross
           section Area of piston , m^2
35     Fs=rho*g*Hs*A;           //Average Force
           during Suction , N
36     Fd=rho*g*Hd*A;           //Average Force
           during Delivery , N
37     P=(Fs+Fd)*L*N/60;           //Power required
           by Pump (Same as Pth) , W
38
39 //Results:-
```

```

40     printf(" 1. Slip=%0.2f Percent \n",Slip)
        //The answer vary due to round off
        error
41     printf(" 2. The Co-efficient of Discharge =
        %0.2f Percent \n",Cd) //The answer
        vary due to round off error
42     printf(" 3. Theoretical Power Required to
        Drive the Pump =%0.2f W \n",Pth) //
        The answer vary due to round off error
43     printf(" 4. Force Required to Work the
        Piston during Suction Stroke =%0.2f N \n"
        ,Fs)
44     printf(" 5. Force Required to Work the
        Piston during Delivery Stroke =%0.2f N \n
        ",Fd)

```

Scilab code Exa 12.2 To Determine 1 The Slip 2 The Coefficient of Discharge 3 Theoretical Power Required to Drive the Pump 4 Force Required to Work the Piston during Suction Stroke 5 Force Required to Work the Piston during Delivery Stroke.

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 12– Reciprocating Pumps
3 //Example 12.2
4 //Referring to Example 12.1
5 //To Determine 1.The Slip 2. The Co-
    efficient of Discharge 3. Theoretical
    Power Required to Drive the Pump 4. Force
    Required to Work the Piston during Suction Stroke
    5. Force Required to Work the Piston during
    Delivery Stroke.
6
7     clc
8     clear
9
10 //Given Data:-
11 //The Pump is Double Acting
12 //From Example 12.1

```



```

13      Hs_th=4.8;           //Suction Head (
      Theoretical), m
14      Hd_th=12;          //Delivery Head (
      Theoretical), m
15      N=90;              //Speed of Pump,
      rpm
16      D=100;             //Piston Diameter, mm
17      L=150;             //Length of Stroke, mm
18      eta_s=60/100;      //Efficiency of
      Suction Stroke
19      eta_d=75/100;      //Efficiency of
      Delivery Stroke
20
21      Q=200;              //Actual Discharge, lit./
      min
22      d=20;              //Diameter of Piston Rod, mm
23
24
25 //Data Used:-
26      rho=1000;          //Density of Water, kg/m^3
27      g=9.81;           //Acceleration due to
      gravity, m/s^2
28
29 //Computations:-
30      A=(%pi/4)*(D/1000)^2; //m^2
31      a=(%pi/4)*(d/1000)^2; //m^2
32      L=L/1000;         //m
33      Vs=2*A*L;         //Swept volume in one
      revolution, m^3
34      Vth=A*L*N/60+(A-a)*L*N/60;
      //Theoretical Volume of Water pumped per
      second, m^3
35      m=Vth*rho;        //Theoretical Mass Flow
      rate, kg/s
36      m_act=Q*1000/(60*1000); //Actual mass
      flow rate, kg/s
37
38      Slip=(m-m_act)*100/m; //Slip in

```

```

Percentage
39 Cd=m_act/m*100; //Co-efficient of
Discharge in Percentage
40 Hs=Hs_th/eta_s; //Suction Head taking
suction efficiency in account, m
41 Hd=Hd_th/eta_d; //Delivery Head taking
delivery efficiency in account, m
42 H=Hs+Hd; //Total Head, m
43 Pth=m*g*H; //Theoretical power
Required to Drive the Pump, W
44 Fb=rho*(Hs*A+Hd*(A-a)); //Force to
be provided by Pump during Backward
Stroke, kg
45 Ff=rho*(Hs*(A-a)+Hd*A); // Force to
be provided by Pump during Forward
Stroke, kg
46
47 //Results:-
48 printf(" 1. Slip=%0.1f Percent \n",Slip)
//The answer vary due to round off
error
49 printf(" 2. The Co-efficient of Discharge =
%0.1f Percent \n",Cd) //The answer
vary due to round off error
50 printf(" 3. Theoretical Power Required to
Drive the Pump =%0.2f W \n",Pth) //
The answer vary due to round off error
51 printf(" 4. Force to be provided by Pump
during Backward Stroke =%0.1f kg \n",Fb)
52 printf(" 5. Force to be provided by Pump
during Forward Stroke =%0.f kg \n",Ff)

```

Scilab code Exa 12.3 To Calculate The Maximum Speed at which pump may be run and D

1 //Fluid Systems – By Shiv Kumar

```

2 //Chapter 12– Reciprocating Pumps
3 //Example 12.3
4 //To Calculate The Maximum Speed at which pump may
   be run and Determine Resultant Suction Head at
   Begining , Middle and End of the Stroke.
5
6     clc
7     clear
8
9 //Given Data:–
10    D=150;           //Diameter of Plunger , mm
11    L=250;           //Stroke length , mm
12    l_s=10;          //Length of Suction Pipe , m
13    d=75;            //Diameter of Suction Pipe , mm
14    hs=4;            //Suction Head, m of water
15    Ha=10.34;        //Atmospheric Pressure , m of
   water
16    Habs=2.44;       //Absolute Pressure Head, m of
   water
17
18 //Data Used:–
19    g=9.81;          //Acceleration due to gravity
   , m/s^2
20
21
22 //Computations:–
23    Hv=Ha-Habs;      //Vaccume Pressure , m of
   water
24    //For Maximum Resultant Suction Head,
25    Hs=Hv;
26    A=(%pi/4)*(D/1000)^2; //m^2
27    a_s= (%pi/4)*(d/1000)^2; //m^2
28    r=L/2000;        //m
29    omega=sqrt((Hs-hs)*g*a_s/(l_s*A*r)); //
   radian/sec
30    N=60*omega/(2*%pi); //rpm
31
32 //Result 1

```

```

33     printf(" The Maximum Speed at which pump may
        be run , N=%0.2 f rpm \n",N)           //The
        answer vary due to round off error
34
35     //At Begining
36     Has=(l_s/g)*(A/a_s)*omega^2*r*cosd(0);    //m
37     Hs=hs+Has;                               //Resultant Head at
        Begining of Stroke , m of water
38
39 //Result 2
40     printf(" Resultant Head at Begining of Stroke ,
        Hs=%0.1 f m of water \n",Hs)
41
42
43     //At Middle
44     Has=(l_s/g)*(A/a_s)*omega^2*r*cosd(90);    //
        m
45     Hs=hs+Has;                               //Resultant Head at Middle of
        Stroke (Has=0), m of water
46
47 //Result 3
48     printf(" Resultant Head at Middle of Stroke ,
        Hs=%0.f m of water \n",Hs)
49
50
51     //At the End
52     Has=(l_s/g)*(A/a_s)*omega^2*r*cosd(180);
        //m
53     Hs=hs+Has;                               //Resultant Head at End
        of Stroke , m of water
54     // Resultant Head at End of Stroke is not
        calculated and displayed as result in
        the textbook.
55
56 //Result 4
57     printf(" Resultant Head at End of Stroke , Hs=%
        .1 f m of water \n ",Hs)

```

Scilab code Exa 12.4 To Find whether separation will take place and if so at which

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 12– Reciprocating Pumps
3 //Example 12.4
4 //To Find whether separation will take place , and if
   so , at which section of pipe .
5
6     clc
7     clear
8
9 //Given Data:–
10     ld=60.96;           //Length of Delivery Pipe ,
   m
11     a=1.83;           //Acceleration of Plunger
   Pump, m/s^2
12     A_by_ad=2;       //ratio of Sectional Area of
   Plunger to that of Delivery Pipe.
13 //Referring to Fig 12.6 in the textbook ,
14     ef=18.3;         //m
15     eq=12.19;       //m
16     dq=1.83;        //m
17     slope=3;
18
19     Hsp=2.44;        //Pressure Head in pipe when
   separation takes place , m of water
20     Hatm=10.36;     //Atmospheric Pressure Head (
   Barometer Reading) , m of water
21
22 //Data Used:–
23     g=9.81;         //Acceleration due to gravity
   , m/s^2
24
25 //Computations:–
```

```

26     Had=- (ld/g)*A_by_ad*a;           //Head
        at end of stroke ,   a=acceleration=omega
        ^2*r,   Had in m
27     dp=Had;   // Referring to Fig 12.6 in the
        textbook
28     ed=eq+dq;
29     Hd=ed;           //Total Delivery Head, m
30     Hrd=Had+Hd;     //Resultant Pressure in
        Delivery pipe at end of Stroke, m
31     Habs=Hatm+Hrd;   //Absolute Pressure. m
        of water
32
33     Hv=Hatm-Hsp;    //Vaccum pressure , m
34     x=-Hv-Had;     //m
35
36     if Habs<Hsp then
37         printf("The Seperation Will Take Place at x=
        %.2f m\n",x)           //The answer vary due
        to round off error
38     else
39         printf("The Seperation Will Not Take Place \
        n")
40     end

```

Scilab code Exa 12.5 To Determine the Pressure Head on Piston at Begining Middle a

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 12– Reciprocating Pumps
3 //Example 12.5
4 //To Determine the Pressure Head on Piston at
    Begining , Middle and End of Suction Stroke.
5
6     clc
7     clear
8

```

```

9 //Given Data:-
10     L=150;           //Length of Stroke , mm
11     l_s=7;          //Length of Suction Pipe , m
12     ds_by_D=3/4;    //Ratio of Suction
                        Pipe Diameter to Piston Diameter , ds/D
13     hs=2.5;         //Suction Head, m
14     ds=75;          //Diameter of Suction Pipe , mm
15     N=75;           //Crank Speed , rpm
16     f=0.01;         //Co-efficient of Friction
17
18
19 //Data Used:-
20     g=9.81;         //Acceleration due to gravity , m/
                        s^2
21     h_atm=10.33;    //Atmospheric Pressure Head
                        , m of water
22
23
24 //Computations:-
25     L=L/1000;       //m
26     ds=ds/1000;    //m
27
28     r=L/2;          //Crank radius , m
29     A_by_as=(1/ds_by_D)^2;
30     omega=2*pi*N/60; //Angular
                        Velocity , rad/s
31
32 //At Begining of Suction Stroke ,
33     theta=0;        //degrees
34     h_as=(l_s/g)*A_by_as*omega^2*r*cosd(theta);
                        //Acceleration Head, m of water
35     h_fs=(4*f*l_s/(2*g*ds))*(A_by_as*omega*r*
                        sind(theta))^2; //Head loss due
                        to friction , m of water
36     h_v=hs+h_fs+h_as; //Pressure Head
                        on Piston , m of water Vaccum
37     h_abs=h_atm-h_v; //Pressure Head on
                        Piston , m of water Absolute

```

```

38 //Result 1
39 printf("At Begining of Suction Stroke\n
      Pressure Head on Piston=%0.2f m of water
      Vaccum \n\t\t\t =%0.2f m of water Absolute\n
\n",h_v,h_abs) //The answer vary due
      to round off error
40
41
42 //At Mid of Suction Stroke,
43 theta=90; //degrees
44 h_as=(l_s/g)*A_by_as*omega^2*r*cosd(theta);
      //Acceleration Head, m of water
45 h_fs=(4*f*l_s/(2*g*ds))*(A_by_as*omega*r*
      sind(theta))^2; //Head loss due
      to friction , m of water
46 h_v=hs+h_fs+h_as; //Pressure Head
      on Piston , m of water Vaccum
47 h_abs=h_atm-h_v; //Pressure Head on
      Piston , m of water Absolute
48 //Result 2
49 printf("At Middle of Suction Stroke\n
      Pressure Head on Piston=%0.4f m of water
      Vaccum \n\t\t\t =%0.3f m of water Absolute\n
\n",h_v,h_abs) //The answer vary due
      to round off error
50
51
52 //At End of Suction Stroke,
53 theta=180; //degrees
54 h_as=(l_s/g)*A_by_as*omega^2*r*cosd(theta);
      //Acceleration Head, m of water
55 h_fs=(4*f*l_s/(2*g*ds))*(A_by_as*omega*r*
      sind(theta))^2; //Head loss due
      to friction , m of water
56 h_v=hs+h_fs+h_as; //Pressure Head
      on Piston , m of water Vaccum
57 h_abs=h_atm-h_v; //Pressure Head on
      Piston , m of water Absolute

```



```

58 //Result 3
59 printf("At End of Suction Stroke\n Pressure
Head on Piston=%0.2f m of water Vaccum \n\t\
t\t =%0.2f m of water Absolute\n\n",h_v,
h_abs) //The answer vary due to round
off error

```

Scilab code Exa 12.6 To Find the Pressure Head on Piston at the begining middle an

```

1 //Fluid Systems – By– Shiv Kumar
2 //Chapter 12– Reciprocating Pumps
3 //Example 12.6
4
5     clc
6     clear
7
8 //Given Data:–
9     D=200; //Piston Diameter, mm
10    L=300; //Stroke length, mm
11    H_s=4; //Suction Head, m
12    H_d=35; //Delivery Head, m
13    d_s=100; //Diameter of Suction Pipe, mm
14    d_d=d_s; //Diameter of Delivery Head
15    l_d=50; //Length of Delivery Pipe, m
16    l_s=10; //Length of Suction Pipe, m
17    f_s=0.04; //Co-efficient of friction for
Suction Pipe
18    f_d=f_s; //Co-efficient of friction for
Delivery Pipe
19    N=30; //Speed of Pump, rpm
20
21
22 //Data Used:–
23    g=9.81; //Acceleration due to gravity
, m/s^2

```

```

24         rho=1000;           //Density of water , kg/m^3
25
26
27 // Computations:-
28         D=D/1000;           //m
29         L=L/1000;           //m
30         d_s=d_s/1000;       //m
31         d_d=d_d/1000;       //m
32
33         a_s=(%pi/4)*d_s^2;    //m^2
34         a_d=(%pi/4)*d_d^2;    //m^2
35         A=(%pi/4)*D^2;       //m^2
36         omega=2*%pi*N/60;    //rad/s
37         r=L/2;               //m
38
39 // (1) Suction Stroke
40 //At end of Stroke ,
41         H_as=(l_s/g)*(A/a_s)*omega^2*r;           //m
           of water
42
43 //At middle of Stroke ,
44         h_fs=f_s*(l_s/d_s)*(1/(2*g))*((A/a_s)*
           omega*r)^2;           //m of water
45
46         H_sb=H_s+H_as;       //Pressure at begining
           of suction stroke , m of water (vaccum)
47         H_se=H_s-H_as;       //Pressure at end of
           suction stroke , m of water
48         H_se=abs(H_se);      //m above atmosphere
49         H_sm=H_s+h_fs;       //Pressure at middle
           of suction stroke , m of water (vaccum)
50
51 // (1) Delivery Stroke
52 //At end of Stroke ,
53         H_ad=(l_d/g)*(A/a_d)*omega^2*r;           //m
           of water
54
55 //At middle of Stroke ,

```

```

56         h_fd=f_d*(l_d/d_d)*(1/(2*g))*((A/a_d)*
           omega*r)^2;           //m of water
57
58     H_db=H_d+H_ad;           //Pressure at begining
           of delivery stroke , m of water (above
           atmosphere)
59     H_de=H_d-H_ad;           //Pressure at end of
           delivery stroke , m of water (above atm
           .)
60     H_dm=H_d+h_fd;           //Pressure at middle
           of delivery stroke , m of water (above
           atm.)
61
62     m=rho*A*L*N/60;           //Mass of Water
           Discharge , kg/s
63     //Referring to Equation 12.18 in the textbook ,
64     Work= m*g*(H_s+H_d+(2/3)*h_fs+(2/3)*h_fd);
           //Total Work done by Pump, W
65
66 //Results:-
67     printf("(1)Suction Stroke\n\t")
68     printf("Pressure at Begining of the Stroke=%
           .2f m of water (vaccum)\n\t",H_sb)
           //The answer vary due to round off error
69     printf("Pressure at End of the Stroke=%0.1f m
           of water (above atmosphere\n\t",H_se)
           //The answer vary due to round off
           error
70     printf("Pressure at Middle of the Stroke=%0.3
           f m of water (vaccum)\n\n",H_sm)           //
           The answer vary due to round off error
71
72     printf("(2)Delivery Stroke\n\t")
73     printf("Pressure at Begining of the Stroke=%
           .2f m of water ( above atmosphere )\n\t",
           H_db)           //The answer vary due to
           round off error
74     printf("Pressure at End of the Stroke=%0.2f m

```

```

        of water (above atm.)\n\t",H_de)
        //The answer vary due to round off error
75     printf(" Pressure at Middle of the Stroke=%0.2
        f m of water ( above atm. )\n",H_dm)
        //The answer vary due to round off
        error
76
77     printf(" Power Required to drive the Pump=%0.2 f
        W",Work) //The answer vary due to
        round off error

```

Scilab code Exa 12.7 To Calculate a The Absolute Head in the Pump corresponding to

```

1 //Fluid Systems – By– Shiv Kumar
2 //Chapter 12– Reciprocating Pumps
3 //Example 12.7
4 //To Calculate (a)The Absolute Head in the Pump
    corresponding to the four corners of the cord and
    also the mid strokes      (b)The Work done/
    minute.
5
6     clc
7     clear
8
9 //Given Data:–
10     D=125; //Bore of the Pump, mm
11     L=125; //Stroke length , mm
12     N=30; //Speed of Pump, rpm
13     H_s=3; //Suction Head, m
14     H_d=15; //Delivery Head, m
15     d_s=62.5; //Diameter of Suction Pipe,
        mm
16     d_d=d_s; //Diameter of Delivery Head
17     l_d=18; //Length of Delivery Pipe, m
18     l_s=l_d; //Length of Suction Pipe

```

```

19         f=0.032;      //Co-efficient of friction for
                both Pipes
20
21
22 //Data Used:-
23         g=9.81;      //Acceleration due to gravity
                , m/s^2
24         rho=1000;    //Density of water, kg/m^3
25         H_a=10.2;    //Atmospheric Pressure Head,
                m of water
26
27 //Computations:-
28         D=D/1000;    //m
29         L=L/1000;    //m
30         d_s=d_s/1000; //m
31         d_d=d_d/1000; //m
32
33         a=(%pi/4)*d_s^2; //m^2
34         A=(%pi/4)*D^2;  //m^2
35         omega=2*%pi*N/60; //rad/s
36         r=L/2;         //m
37
38         H_as=(l_s/g)*(A/a)*omega^2*r; //m
39         h_fs_max=f*(l_s/d_s)*(1/(2*g))*((A/a)*omega*
                r)^2; //m
40 //As Pipes are of same diameter and length ,
41         H_ad=H_as;
42         h_fd_max=h_fs_max;
43
44         H_m=H_a-H_s-H_as; //Pressure Head at
                'm' , m of water
45         H_r= H_a-H_s-h_fs_max ; //Pressure
                Head at 'r' , m of water
46         H_n=H_a-H_s+H_as ; //Pressure Head at
                'n' , m of water
47         H_at_s= H_a+H_s+H_as ; //Pressure
                Head at 's' , m of water
48         H_o=H_a+H_d+h_fd_max ; //Pressure

```

```

        Head at 'o' , m of water
49     H_q=H_a+H_d+H_ad ;           //Pressure Head at
        'q' , m of water
50
51     m=rho*A*L*N*2/60;           //mass of water/s, kg/
        s
52     Work_s=m*g*(H_s+H_d+(2/3)*h_fs_max+(2/3)*
        h_fd_max);           //Work done/s, W
53     Work_m=Work_s*60;           //Work done/min. , J/min
54
55 //Results:-
56     printf(" Pressure Head at m =%.2f m of water\n
        ",H_m)           //The answer vary due to round
        off error
57     printf(" Pressure Head at r =%.3f m of water\n
        ",H_r)           //The answer vary due to round
        off error
58     printf(" Pressure Head at n =%.2f m of water\n
        ",H_n)           //The answer provided in the
        textbook is wrong
59     printf(" Pressure Head at s =%.2f m of water\n
        ",H_at_s )           //The answer provided in the
        textbook is wrong
60     printf(" Pressure Head at o =%.3f m of water\n
        ",H_o)           //The answer vary due to round
        off error
61     printf(" Pressure Head at q =%.2f m of water\n\
        n ",H_q)           //The answer provided in the
        textbook is wrong
62
63     printf(" Work done/s=%.1f W \n Work done/
        minute=%.2f J/min. \n",Work_s,Work_m)
        //The answer provided in the textbook
        is wrong

```

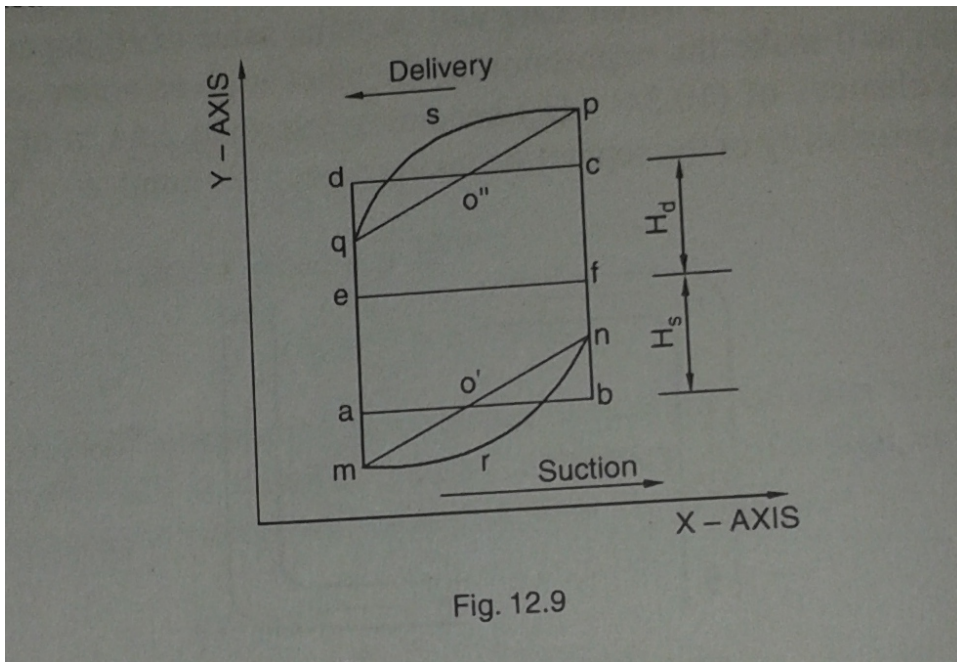


Figure 12.1: To Calculate a The Absolute Head in the Pump corresponding to the four corners of the cord and also the mid strokes b The Work done per minute

Scilab code Exa 12.8 To a Find the Speed at which separation may take place at com

```
1 //Fluid Systems – By– Shiv Kumar
2 //Chapter 12– Reciprocating Pumps
3 //Example 12.8
4 //To (a) Find the Speed at which separation may
   take place at commencement of suction stroke ,
   (b)Find the change in Speed of Pump if an
   air vessel is fitted in the suction side.
5
6     clc
7     clear
8
9 //Given Data:–
10     H_s=3.60;           //Suction Head, m
11     d_s=225;           //Diameter of Suction Pipe, mm
12     l_s=9.6;           //Length of Suction Pipe, m
13     D=300;             //Pump cylinder diameter, mm
14     L=450;             //Stroke length, mm
15
16     H_a=9.6;           //Barometric Head, m of water
17     H_sp=2.4;          //Head (m of water) for
   separation
18     f=0.04;
19
20
21 //Data Used:–
22     g=9.81;            //Acceleration due to gravity
   , m/s^2
23
24
25 //Computations:–
26     D=D/1000;         //m
27     L=L/1000;         //m
```



```

28         d_s=d_s/1000;           //m
29
30         a_s=(%pi/4)*d_s^2;       //m^2
31         A=(%pi/4)*D^2;           //m^2
32         r=L/2;                   //m
33
34         //Without Air Vessel
35         H_as_by_omega2=(l_s/g)*(A/a_s)*r;           //
36         H_as/omega^2
37         omega=sqrt((H_a-H_s-H_sp)/H_as_by_omega2);
38         //rad/s
39         N=omega*60/(2*%pi);       //rpm
40
41         //With Air Vessel
42         Us_by_N=(A/a_s)*L/60;     //Us/N
43         l_v=H_sp/2;               //m
44         H_as_by_N2=(l_v/g)*(A/a_s)*(2*%pi/60)^2*r;
45         //H_as/N^2
46         h_fs_by_N2=f*(l_s-l_v)*Us_by_N^2/(r*2*g);
47         N1=sqrt((H_a-H_sp-H_s)/(H_as_by_N2+
48         h_fs_by_N2));           //Speed of Pump if
49         air vessel is fitted , rpm
50         Change_In_Speed=N1-N;     //rpm
51
52         //Results:-
53         printf("(a)Speed at which Seperation may
54         take place , N=%f rpm\n",N)
55         printf("(b)Change in Speed with air vessel=%
56         .f rpm\n",Change_In_Speed) //The
57         answer provided in the textbook is wrong

```

Scilab code Exa 12.9 To Determine the Pressure on the Cylinder at the Beginning of

1 //Fluid Systems – By – Shiv Kumar

```

2 //Chapter 12– Reciprocating Pumps
3 //Example 12.9
4 //To Determine the Pressure on the Cylinder at the
   Beginning of the Stroke      (a)When no air
   vessel is fitted ,          (b)When air vessel is
   fitted at the cylinder level.

5
6     clc
7     clear
8
9 //Given Data:–
10    d_s=150;           //Diameter of Suction Pipe ,
        mm
11    l_s=12;           //Length of Suction pipe , m
12    H_s=3;           //Suction Head, m
13    D=225;           //Cylinder Diameter, mm
14    L_s=375;         //Stroke Length, mm
15    L=1.5;           //Length of Connecting Rod, m
16    N=20;           //Crank Speed, rpm
17    l_v=1.5;         //m
18    f=0.04;         //Co-efficient of friction
19
20 //Data Used:–
21    g=9.81;         //Acceleration due to gravity, m
        /s^2
22
23 //Computations:–
24    d_s=d_s/1000;     //m
25    D=D/1000;        //m
26    L_s=L_s/1000;    //m
27
28    a_s=(%pi/4)*d_s^2; //m^2
29    A=(%pi/4)*D^2;    //m^2
30    omega=2*%pi*N/60; //rad/s
31    r=L_s/2;         //m
32
33    printf(" Without Air Vessel : \n\t")
34    //(i) Assuming Simple Harmonic Motion :

```

```

35         printf(" (i) Assuming Simple
           Harmonic Motion\n\t\t")
36         H_as=(l_s/g)*(A/a_s)*omega^2*r;
           //m of water
37         H=H_s+H_as;           //Pressure at
           the begining of stroke , m of
           water (vaccum)
38         //Result (a) (i)
39         printf(" Pressure at the begining of
           stroke=%0.2f m of water (vaccum)
           \n\t",H)           //The answer vary
           due to round off error
40
41         //(ii) If Simple Harmonic Motion is not
           assumed :
42         printf(" (ii) If Simple Harmonic
           Motion is not assumed : \n\t\t"
           )
43         H_as=H_as*(1+r/L);
44         H=H_s+H_as;           //Pressure at
           the begining of stroke , m of
           water (vaccum)
45         //Result (a) (ii)
46         printf(" Pressure at the begining of
           stroke=%0.3f m of water (vaccum)
           \n\n",H)           //The answer vary
           due to round off error
47
48
49         //(b) When Air Vessel is fitted
50         printf(" When Air Vessel is fitted : \n\t"
           )
51
52         Us=(A/a_s)*L_s*N/60;           //m/s
53         h_fs=(f*(l_s-l_v)/d_s)*(Us^2/(2*g));
           //m of water
54
55         //(i) Assuming Simple Harmonic Motion :

```

```

56         printf(" (i) Assuming Simple
           Harmonic Motion\n\t\t")
57         H_as=(l_v/g)*(A/a_s)*omega^2*r;
           //m of water (vaccum)
58         H=H_s+H_as+h_fs;           //Total
           Pressure Head in the Cylinder
           , m of water below
           atmospheric
59     //Result (b) (i)
60         printf(" Total Pressure Head in the
           Cylinder =%.4f m of water below
           atmospheric or vaccum \n\t",H)
           //The answer vary due to
           round off error
61
62     //(ii) If Simple Harmonic Motion is not
           assumed :
63         printf(" (ii) If Simple Harmonic
           Motion is not assumed : \n\t\t"
           )
64         H_as=H_as*(1+r/L);
65         H=H_s+H_as+h_fs;           // Total
           Pressure Head in the Cylinder
           , m of water below atmospheric
66     //Result (b) (ii)
67         printf(" Total Pressure Head in the
           Cylinder =%.4f m of water below
           atmospheric \n",H)           //The
           answer vary due to round off
           error

```

Scilab code Exa 12.10 To Find the Power required to overcome the friction of Deliv

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 12– Reciprocating Pumps

```

```

3 //Example 12.10
4 //To Find the Power required to overcome the
   friction of Delivery pipe when      (a)No air
   vessel is fitted on it ,           (b)A large air
   vessel is fitted at the centre line of the pump.
5
6     clc
7     clear
8
9 //Given Data:-
10    N=60;           //Speed of the Pump, rpm
11    D=250;         //Plunger Diameter, mm
12    L=450;         //Stroke Length, mm
13    d_d=112.5;     //Diameter of Delivery Pipe
   , mm
14    l_d=48;        //Length of Delivery Pipe, m
15    f=0.04;       //Co-efficient of friction
16
17 //Data Used:-
18    g=9.81;        //Acceleration due to gravity, m
   /s^2
19    rho=1000;     //Density of water, kg/m^3
20
21
22 //Computations:-
23    d_d=d_d/1000; //m
24    D=D/1000;    //m
25    L=L/1000;    //m
26
27    a=(%pi/4)*d_d^2; //m^2
28    A=(%pi/4)*D^2;  //m^2
29    omega=2*%pi*N/60; //rad/s
30    r=L/2;         //m
31
32 // (a) Without Air Vessel
33    H_fd=f*(l_d/d_d)*(omega*r*A/a)^2/(2*g);
   //Maximum loss of head due to
   friction in delivery pipe, m

```

```

34         m=rho*A*L*N/60;           //Mass of water
           lifted , kg/s
35         Power=(2/3)*H_fd*m;       //W
36
37     //Result (a)
38     printf("(a) Without Air Vessel\n\t")
39     printf("Power Required to Overcome
           Friction=%0.2 f W\n\n",Power)      //
           The answer provided in the textbook
           is wrong
40
41     //(b) With Air Vessel
42     Ud=A*L*N/(a*60);              //m/s
43     H_fd=f*(l_d/d_d)*(Ud^2/(2*g)); //m
44     Power=m*H_fd;                 //W
45     //Result (a)
46     printf("(a) With Air Vessel\n\t")
47     printf("Power Required to Overcome
           Friction=%0.2 f W\n",Power)      //The
           answer vary due to round off error

```

Scilab code Exa 12.11 c To Find the Rate of flow into or from the air vessel when

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 12– Reciprocating Pumps
3 //Example 12.11
4 //(a) Theoretical Question.
5 //(b) Theoretical Question.
6 //(c) To Find the Rate of flow into or from the air
           vessel when crank makes angle of 30, 90 and 120
           degrees with inner dead centre and
7     //Also Determine crank angle at which there is
           no flow to or from the air vessel.
8
9     clc

```

```

10         clear
11
12 //Given Data:-
13         D=200;           //Bore of the Pump, mm
14         L=350;           //Stroke Length, mm
15         d_s=150;         //Diameter of Suction Pipe,
                             mm
16         N=120;           //Speed of the Pump, rpm
17
18
19 //Computations:-
20         d_s=d_s/1000;     //m
21         D=D/1000;         //m
22         L=L/1000;         //m
23
24         A=(%pi/4)*D^2;     //m^2
25         omega=2*%pi*N/60; //rad/s
26         r=L/2;           //m
27
28 //Using the Equation 12.28 from the textbook
29 // , Rates of Flow are
30         Q_30=A*omega*r*(2/%pi-sind(30) )*1000;
31 //For 30 degree angle, litres/s
32         Q_90=A*omega*r*(2/%pi-sind(90) )*1000;
33 //For 90 degree angle, litres/s
34         Q_120=A*omega*r*(2/%pi-sind(120) )*1000;
35 //For 120 degree angle, litres/s
36
37         theta=asind(2/%pi); //Angle at which
38 // there is no flow, degrees
39 //This is NOT Calculated in the Textbook
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    t\t\t",Q_90)
39  printf(" =%.1f litre/s   for 120 Degree Angle\n"
    ,Q_120)
40
41  printf("The angle at which there is no flow
    from or to the air vessel = %.2f Degrees\n"
    ,theta)

```

Scilab code Exa 12.12 To Find the Maximum Speed at which the Pump may run without

```

1  //Fluid Systems – By – Shiv Kumar
2  //Chapter 12– Reciprocating Pumps
3  //Example 12.12
4  //To Find the Maximum Speed at which the Pump may
    run without seperation.
5
6      clc
7      clear
8
9  //Given Data:–
10     D=10;          //Plunger Diameter , cm
11     L=20;          //Stroke Length , cm
12     H_s=4;         //Suction Head, m
13     H_d=14;        //Delivery Head, m
14     d_s=4;         //Diameter of Suction Pipe , cm
15     l_s=6;         //Length of Suction Pipe , m
16     d_d=3;         //Diameter of Delivery Pipe , cm
17     l_d=18;        //Length of Delivery Pipe , m
18     p=7.85;        //Pressure (below atm.) for
        seperation , N/cm^2
19     H_a=10.3;      //Atmospheric Pressure
        Head, m of water
20
21
22  //Data Used:–

```



```

23      g=9.81;          //Acceleration due to gravity , m
                /s^2
24      rho=1000;      //Density of water , kg/m^3
25
26
27 //Computations:-
28      d_s=d_s/100;    //m
29      d_d=d_d/100;    //m
30      D=D/100;        //m
31      L=L/100;        //m
32
33      a_s=(%pi/4)*d_s^2; //m^2
34      a_d=(%pi/4)*d_d^2; //m^2
35      A=(%pi/4)*D^2;    //m^2
36      r=L/2;           //m
37
38      H_sp=p*100^2/(rho*g); //Pressure Head of
                water for seperation , m (below
                atmosphere) (Value given in textbook
                is wrong due to incorrect value of p is
                used)
39      H_abs=H_a-H_sp; //Absolute Pressure
                Head of water for seperation , m
40      H_as_by_omega2=(l_s/g)*(A/a_s)*r; //
                H_as/omega^2
41      omega=sqrt((H_sp-H_s)/H_as_by_omega2); //
                rad/s
42      N_s=omega*60/(2*%pi); //rpm
43
44      H_ad_by_omega2=(l_d/g)*(A/a_d)*r; //
                H_as/omega^2
45      omega=sqrt((H_sp+H_d)/H_ad_by_omega2); //
                rad/s
46      N_d=omega*60/(2*%pi); //rpm
47
48 //Selecting maximum speed ,
49 if N_s>N_d then
50     N=N_s;

```

```

51     else
52         N=N_d;
53
54 //Result:-
55     printf("Hence, The Maximum Speed at which Pump
           should be Run is %.2f rpm\n",N)           //The
           answer vary due to round off error

```

Scilab code Exa 12.13 To Determine the Crank Angle at which there is no flow of wa

```

1 //Fluid Systems – By – Shiv Kumar
2 //Chapter 12– Reciprocating Pumps
3 //Example 12.13
4 //To Determine the Crank Angle, at which there is
   no flow of water to or from the vessel.
5
6     clc
7     clear
8
9 //Given Data:-
10    D=17.5;           //Bore diameter, cm
11    L=35;             //Stroke Length, cm
12    d_s=15;          //Diameter of Suction pipe, cm
13    N=150;           //Speed, rpm
14
15 //Computations:-
16    D=D/100;         //m
17    L=L/100;         //m
18    d_s=d_s/100;    //m
19
20    omega=2*%pi*N/60; //rad/s
21    A=(%pi/4)*D^2;   //m^2
22    r=L/2;           //m
23    Q_s=2*A*omega*r/%pi; //Rate of flow from
           sump upto air vessel, m^3/s

```

```
24         theta=asind(Q_s/(A*omega*r));           //degrees
25
26
27 //Result:-
28         printf("The Crank Angle at which there is
                no flow , theta=%0.2f Degrees\n",theta)
```

Chapter 16

Hydraulic Power and Its Transmission

Scilab code Exa 16.1 To Find the Maximum Power Available at the Outlet of Pipe

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 16– Hydraulic Power and Its Transmissions
3 //Example 16.1
4 //To Find the Maximum Power Available at the Outlet
  of Pipe .
5     clc
6     clear
7
8 //Given Data:–
9     d=300;           //Diameter of the Pipe , mm
10    l=3000;          //Length of the Pipe , m
11    H=400;           //Total Head at Inlet , m
12    f=0.005;
13
14 //Data Required:–
15    rho=1000;        //Density of Water, Kg/m^3
16    g=9.81;         //Acceleration due to gravity ,
    m/s^2
17
```

```

18 //Computations:-
19 //Condition for Maximum Power transmission
20 hf=H/3; //m
21 V=sqrt(hf*(2*g*d/1000)/(4*f*1)); //m/s
22 Q=(%pi/4)*(d/1000)^2*V; //Discharge , m
    ^3/s
23 Pmax=rho*g*Q*(H-hf)/1000; //Maximum
    Power Available at Outlet of Pipe , kW
24
25
26 //Results:-
27 printf("The Maximum Power Available at Outlet of
    Pipe=%0.3 f kW" ,Pmax) //The answer vary
    due to round off error

```

Scilab code Exa 16.2 To Determine the Flow Rate and the Minimum Diameter of Pipe

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 16– Hydraulic Power and Its Transmissions
3 //Example 16.2
4 //To Determine the Flow Rate and the Minimum
    Diameter of Pipe.
5     clc
6     clear
7
8 //Given Data:-
9     P=1000; //Power Transmitted , kW
10    eta=85/100; //Efficiency
11    l=500; //Length of the Pipe , m
12    H=150; //Head of Water at Inlet , m
13    f=0.006;
14
15 //Data Required:-
16    rho=1000; //Density of Water , Kg/m^3
17    g=9.81; //Acceleration due to gravity ,

```

```

18
19 // Computations:-
20     hf=H*(1-eta); //m
21     Q=P*10^3/(rho*g*(H-hf)); //m^3/s
22     d=(64*f*1*Q^2/(2*g*pi^2*hf))^(1/5); //m
23
24 // Results:-
25     printf("The Required Flow Rate, Q=%0.4 f m^3/
26           s\n",Q)
27     printf("The Minimum Diameter, d=%0.4 f m\n",d
28           ) //The answer vary due to round
29           off error

```

Scilab code Exa 16.3 To Determine the Minimum Number of Pipes

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 16– Hydraulic Power and Its Transmissions
3 //Example 16.3
4 //To Determine the Minimum Number of Pipes.
5     clc
6     clear
7
8 //Given Data:-
9     l=7500; //Length of each Pipe, m
10    d=125; //Diameter of each Pipe, mm
11    Pr=6000; //Pressure at Discharge End, kPa
12    eta=85/100; //Efficiency
13    P=156; //Power Delivered, kW
14    f=0.006;
15
16 //Data Required:-
17    rho=1000; //Density of Water, Kg/m^3
18    g=9.81; //Acceleration due to gravity,
19           m/s^2

```

```

19
20 // Computations:-
21     H_minus_hf=Pr*10^3/(rho*g);           //H-hf, m
22     H=H_minus_hf/eta;                    //m
23     hf=H-H_minus_hf;                     //m
24     Q=P*1000/(rho*g*(H-hf));             //m^3/s
25     q=sqrt((hf*2*g*pi^2*(d/1000)^5)/(64*f*1))
        ; // Discharge in each Pipe, m^3/s
26     n=Q/q;                               //Number of Pipes
27
28
29 // Results:-
30
31     printf("The Minimum Number of Pipes
        Required=%f\n",n)

```

Scilab code Exa 16.4 To Find the Diameter of Pipe

```

1 // Fluid Systems – By Shiv Kumar
2 // Chapter 16– Hydraulic Power and Its Transmissions
3 // Example 16.4
4 // To Find the Diameter of Pipe.
5     clc
6     clear
7
8 // Given Data:-
9     l=2100; //Length of the Pipe, m
10    P=103; //Power Transmitted, kW
11    pi=392.4; //Pressure at Inlet of Pipe, N/cm
        ^2
12    eta=80/100; //Efficiency
13    f=0.005;
14
15 // Data Required:-
16    rho=1000; //Density of Water, Kg/m^3

```

```

17         g=9.81;           //Acceleration due to gravity ,
                m/s^2
18
19 //Computations:-
20         H=pi*10^4/(rho*g);           //m
21         hf=H*(1-eta);           //m
22         Q=P*1000/(rho*g*(H-hf));           //m^3/s
23         d=((64*f*1*Q^2)/(hf*2*g*%pi^2))^(1/5)*1000;
                //mm
24
25
26 //Results:-
27
28         printf("The Diameter of Pipe=%0.2f mm\n",d)
                //The answer vary due to round off
                error

```

Scilab code Exa 16.5 To Calculate the Increase in Pressure Intensity

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 16– Hydraulic Power and Its Transmissions
3 //Example 16.5
4 //To Calculate the Increase in Pressure Intensity.
5     clc
6     clear
7
8 //Given Data:-
9     d=200; //diameter of Pipe , mm
10    Q=40; //Discharge , Litres/s
11    l=600; //Length of Pipe , m
12    t=1.5; //Time taken to close the
            Valve gradually , s
13
14 //Data Required:-
15    rho=1000; //Density of Water , Kg/m^3

```



```

16
17 // Computations:-
18     A=(%pi/4)*(d/1000)^2;           //m^2
19     V=(Q/1000)/A;                 //m/s
20     p=rho*l*V/(t*1000);           //Pressure Rise,
                                   kPa
21
22
23 // Results:-
24
25     printf("The Pressure Rise due to Gradual
              Closure of Valve=%f kPa\n",p) //
              The answer vary due to round off error

```

Scilab code Exa 16.6 To Calculate the Rise in Pressure due to Valve Closure in i 1

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 16– Hydraulic Power and Its Transmissions
3 //Example 16.6
4 //To Calculate the Rise in Pressure due to Valve
  Closure in (i)10 seconds, (ii)2.5 seconds.
5     clc
6     clear
7
8 //Given Data:-
9     l=2500;                       //Lenfth of Pipe, m
10    V=1.2 ;                        //Velocity of Flow, m/
                                   s
11    K=20*10^8;                     //Bulk Modulus of Water,
                                   N/m^2
12
13 //Data Used:-
14    rho=1000;                       //Density of Water, Kg/m^3
15
16 // Computations:-

```

```

17         a=sqrt(K/rho);           //Velocity of
           Pressure Wave, m/s
18         t_c=2*1 /a;             //Critical time, s
19
20     // (i)
21         t=10;                   // s
22         //t>t_c. so, This is a case of Gradual
           valve closure.
23         p=rho*1*V/(t*1000);     //Pressure
           Rise, kPa
24
25     //Result (i)
26         printf("(i)Pressure Rise, p=%0.f kPa\n",p)
27
28     //(ii)
29         t=2.5;                  // s
30         // t<t_c. This is a case of Instantaneous
           Valve Closure.
31         p=rho*V*a/1000;         // Pressure Rise
           , kPa
32
33     //Result (ii)
34         printf("(ii)Pressure Rise, p=%0.2f kPa\n",p
           ) //The answer vary due to round
           off error

```

Scilab code Exa 16.7 To Determine the Increase in Pressure

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 16– Hydraulic Power and Its Transmissions
3 //Example 16.7
4 //To Determine the Increase in Pressure.
5     clc
6     clear
7

```

```

8 //Given Data:-
9     d=800;           //Diameter of pipe , mm
10    Q=0.75;         //Discharge , m^3/s
11    t=10;           //Thickness of Pipe ,
12                    nmmm
13    Es=20*10^10;    //Elastic Modulus of
14                    Steel , N/m^2
15    E=2*10^9;       //Elastic Modulus of Water
16                    , N/m^2
17    l=3500;         //Lenfth of Pipe , m
18    T=5;           //Time of Valve Closure , s
19
20 //Data Used:-
21 rho=1000;         //Density of Water , Kg/m^3
22
23 //Computations:-
24 K=E/(1+(d/t)*(E/Es)); //Combined
25                    Modulus of Elasticity , N/m^2
26 a=sqrt(K/rho);     //Velocity of
27                    Pressure Wave, m/s
28 Tc=2*l /a;        //Critical time, s
29
30 //t<t_c. So, valve closure is rapid.
31 A=(%pi/4)*(d/1000)^2; //m^2
32 V=Q/A;           //Average Velocity
33                    of Flow , m/s
34 p=rho*V*a/1000; //Pressure Rise
35                    , kPa
36
37 //Result
38 printf("The Rise of Pressure=%0.2f kPa\n",p
39 ) //The answer provided in the
40 textbook is wrong

```

Scilab code Exa 16.8 To Find i Displacement of Accumulator ii Capacity of Accumula

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 16– Hydraulic Power and Its Transmissions
3 //Example 16.8
4 //To Find (i) Displacement of Accumulator (ii)
  Capacity of Accumulator (iii) Total weight
  placed on the ram.
5     clc
6     clear
7
8 //Given Data:–
9     p=200;           //Pressure of oil , kPa
10    D=1.5;          //Diameter of Ram, m
11    L=6;            //Stroke or Lift of Ram, m
12
13 //Computations:–
14    A=(%pi/4)*D^2;   //m^2
15    Disp=A*L;        //Displacenment of
  Accumulator , m^3
16    Capacity=p*Disp; //Capacity of
  Accumulator , kNm
17    W=p*A;          //Total Weight on the Ram, kN
18
19 //Results:–
20    printf("(i) Displacenment of Accumulator=%0.2f m
  ^3\n ",Disp) //The answer vary due to
  round off error
21    printf("(ii) Capacity of Accumulator =%0.f kNm \n
  ",Capacity) //The answer given in the
  textbook is wrong
22    printf("(iii) Total Weight on the Ram, W =%0.1f
  kN \n ",W) //The answer vary due to
  round off error

```

Scilab code Exa 16.9 To Determine the Diameter of the ram

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 16– Hydraulic Power and Its Transmissions
3 //Example 16.9
4 //To Determine the Diameter of the ram.
5     clc
6     clear
7
8 //Given Data:–
9     d=125;           //Diameter of Pipe , mm
10    l=2;             //Lenght of Pipe , km
11    P=35;            //Power Transmitted , kW
12    W=1250;          //Load on ram , kN
13    loss_per=3;      //Percentage of Power Loss
                        due to friction
14    f_dash=0.04;    //Pipe Friction Factor
15
16 //Data Used:–
17    rho=1000;        //Density of Water , kg/m^3
18    g=9.81;          //Acceleration due to gravity ,
                        m/s^2
19
20 //Computations:–
21    Delta_P=loss_per/100*P*1000;           //Power
                        Loss due to friction , W
22    //By Darcy's Formula ,
23    hf_by_V2=f_dash*(l*1000)/(2*g*d/1000);
                        //hf/V^2
24
25    QbyV=(%pi/4)*(d/1000)^2;              //Q/V
26    V=( Delta_P/(rho*g*QbyV*hf_by_V2))^(1/3);
                        //m/s
27    Q=QbyV*V;                             //m^3/s

```

```

28     p=P*1000/Q;           //N/m^2
29     D=sqrt(W*1000/(p*pi/4))*1000;           //mm
30
31 //Result:-
32     printf("The Diameter of ram, D=%.2f mm",D)
           //The answer vary due to round off
           error

```

Scilab code Exa 16.10 To Find i The Weight of Loaded Cylinder and energy stored by

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 16– Hydraulic Power and Its Transmissions
3 //Example 16.10
4 //To Find (i)The Weight of Loaded Cylinder and
   energy stored by the Cylinder (ii)Ther Power
   supplied by the Accumulator (iii)The Diameter
   of ram of an ordinary Accumulator.
5     clc
6     clear
7
8 //Given Data:-
9     D=180;           // mm
10    d=150;           //mm
11    L=1.25;         //Stroke length , m
12    p=100;          //Pressure of Water, bar
13
14 //Computations:-
15    D=D/1000;       //m
16    d=d/1000;       //m
17    p=p*10^5;       //N/m^2
18
19    A=(%pi/4)*(D^2-d^2);           //Annular area of
   Ram, m^2
20 // (i)
21    W=p*A/1000;           //Weight of Loaded

```

```

                Cylinder , kN
22         Energy=W*L;           //Energy stored in the
                Accumulator , kNm
23         //(ii)
24         t=90;           //Time taken by ram to
                complete the stroke , seconds
25         P=W*L/t;           //kW
26         //(iii)
27         D=(W*1000/(p*pi/4))^(1/2)*1000;
                //mm
28
29 //Results:-
30         printf("(i)Weight of Loaded Cylinder , W=%0.2
                f kN\n",W)           //The answer vary due
                to round off error
31         printf("        Energy stored in the
                Accumulator=%0.3 f kNm\n",Energy)
                //The answer vary due to round
                off error
32         printf("(ii)Power Supplied by the
                Accumulator=%0.3 f kW\n",P)           //The
                answer vary due to round off error
33         printf("(iii)Ram Diameter (In case of
                Ordinary Accumulator) = %0.2 f mm\n",D)
                //The answer vary due to round off
                error

```

Scilab code Exa 16.11 To Find the Diameters of Fixed ram and Sliding Cylinder

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 16– Hydraulic Power and Its Transmissions
3 //Example 16.11
4 //To Find the Diameters of Fixed ram and Sliding
    Cylinder.
5         clc

```

```

6      clear
7
8  //Given Data:-
9      p1=50;           //Pressure Intensity of
      Low Pressure Liquid, bar
10     p2=150;          // Pressure Intensity of
      High Pressure Liquid, bar
11     Capacity=32;     //Capacity of
      Intensifier, Litres
12     l=1.5;           //Stroke Length, m
13
14  //Computations:-
15     Capacity=Capacity/1000;           //m^3
16
17     D2=sqrt(Capacity/((%pi/4)*l))*1000;
      //mm
18     D1=sqrt((p2/p1)*D2^2);           //mm
19
20  //Results:-
21     printf("Diameter of Fixed Cylinder, D2=%0.2 f
      mm\n",D2)           //The answer vary due
      to round off error
22     printf("Diameter of Sliding Ram, D1=%0.2 f mm
      \n",D1)           //The answer vary due to
      round off error

```

Scilab code Exa 16.12 To Calculate the Diameters of Fixed ram and Sliding Cylinder

```

1  //Fluid Systems – By Shiv Kumar
2  //Chapter 16– Hydraulic Power and Its Transmissions
3  //Example 16.12
4  //To Calculate the Diameters of Fixed ram and
      Sliding Cylinder.
5      clc
6      clear

```



```

7
8 //Given Data:-
9     p1=50;           //Pressure Intensity of
        Low Pressure Liquid, bar
10    p2=150;         // Pressure Intensity of
        High Pressure Liquid, bar
11    Capacity=0.025; //Capacity of
        Intensifier, m^3
12    l=1.25;        //Stroke Length, m
13
14 //Computations:-
15
16    D2=sqrt(Capacity/((%pi/4)*l))*1000;
        //mm
17    D1=sqrt((p2/p1)*D2^2);           //mm
18
19 //Results:-
20    printf("Diameter of Fixed Cylinder, D2=%0.2 f
        mm\n",D2)           //The answer vary due
        to round off error
21    printf("Diameter of Sliding Ram, D1=%0.2 f mm\
        n",D1)           //The answer vary due to
        round off error

```

Scilab code Exa 16.13 To Find the Diameter of Cylinder

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 16– Hydraulic Power and Its Transmissions
3 //Example 16.13
4 //To Find the Diameter of Cylinder.
5     clc
6     clear
7
8 //Given Data:-
9     F=400;           //Force, N

```

```

10         p=4000;           //Pressure , kPa
11
12 //Computations:-
13
14         d=sqrt(4*F/(%pi*p*1000))*1000;           //
           mm
15
16 //Results;-
17         printf(" Cylinder Diameter , d=%0.2 f mm\n" ,d)

```

Scilab code Exa 16.14 To Find i The Force applied in Plunger ii The Number of Stro

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 16– Hydraulic Power and Its Transmissions
3 //Example 16.14
4 //To Find (i)The Force applied in Plunger (ii)
   The Number of Strokes performed by Plunger
   (iii) Work done by the Press Ram and
   (iv) Power required to drive the Plunger.
5
6     clc
7     clear
8
9 //Given Data:-
10     D=180;           //Diameter of ram, mm
11     d=36;           //Diameter of Plunger, mm
12     W=7 ;           //Weight exerted by Press ram,
           kN
13     L=300;           //Stroke Length of Plunger ,
           mm
14     l=0.9;           //Distance moved by ram, m
15     t=15;           //Time, minutes
16
17 //Computations:-
18     D=D/1000;           //m

```

```

19     A=(%pi/4)*D^2;           //m^2
20     d=d/1000;               //m
21     a= (%pi/4)*d^2;         //m^2
22     W=W*1000;               //N
23     L=L/1000;               //m
24     t=t*60;                 //seconds(s)
25
26     // (i)The Force applied in Plunger , F1
27     F1=(a/A)*W;             //N
28
29     //(ii) The Number of Strokes performed by
30     Plunger , n
31     n=(A/a)*(l/L);
32     // (iii) Work done by the Press Ram
33     Work=W*l;               //N-m
34
35     // (iv) Power required to drive the Plunger , P
36     P=Work/t;               //W
37
38
39     //Results:-
40     printf(" (i) The Force applied in Plunger ,
41     F1=%0.2 f N \n" ,F1)           //The answer
42     vary due to round off error
43     printf(" (ii) The Number of Strokes
44     performed by Plunger , n =%.f \n" ,n)
45     printf(" (iii) Work done by the Press Ram =
46     %.f N.m \n" ,Work)
47     printf(" (iv) Power required to drive the
48     Plunger , P =%.f W \n" ,P)

```

Scilab code Exa 16.15 To Find i The Force applied in Plunger ii The Number of Stro

1 //Fluid Systems – By Shiv Kumar

```

2 //Chapter 16– Hydraulic Power and Its Transmissions
3 //Example 16.15
4 //To Find (i)The Force applied in Plunger (ii)
    The Number of Strokes performed by Plunger
    (iii) Work done by the Press Ram and
    (iv) Power required to drive the Plunger.
5
6     clc
7     clear
8
9 //Given Data:–
10     D=165;           //Diameter of ram, mm
11     d=33;           //Diameter of Plunger, mm
12     W=5.5;         //Weight exerted by Press ram,
        kN
13     L=250;         //Stroke Length of Plunger,
        mm
14     l=1.2;         //Distance moved by ram, m
15     t=20;          //Time, minutes
16
17 //Computations:–
18     D=D/1000;      //m
19     A=(%pi/4)*D^2; //m^2
20     d=d/1000;      //m
21     a=(%pi/4)*d^2; //m^2
22     W=W*1000;      //N
23     L=L/1000;      //m
24     t=t*60;        //seconds(s)
25
26     // (i)The Force applied in Plunger, F1
27     F1=(a/A)*W;    //N
28
29     //(ii) The Number of Strokes performed by
        Plunger, n
30     n=(A/a)*(l/L);
31
32     //(iii) Work done by the Press Ram
33     Work=W*l;      //N–m

```

```

34
35 // (iv) Power required to drive the Plunger , P
36 P=Work/t; //W
37
38
39 //Results:-
40 printf(" (i) The Force applied in Plunger ,
    F1=%f N \n",F1)
41 printf(" (ii) The Number of Strokes
    performed by Plunger , n =%f \n",n)
42 printf(" (iii) Work done by the Press Ram =
    %f N.m \n",Work)
43 printf(" (iv) Power required to drive the
    Plunger , P =%.1f W \n",P)

```

Scilab code Exa 16.16 To Find i Power required to drive the Lift ii Working Period

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 16– Hydraulic Power and Its Transmissions
3 //Example 16.16
4 //To Find (i) Power required to drive the Lift
    (ii) Working Period of Lift and (iii)
    Ideal Period of Lift.
5
6 clc
7 clear
8
9 //Given Data:-
10 W=60; //Load lifted by Lift , kN
11 H=14; //Height, m
12 V=0.5; //Speed of Lift , m/s
13 t=60; //Time for one operation , s
14
15 //Computations:-
16

```

```

17 // (i) Power required to drive the Lift , P
18     P=W*H/t;           //kJ/s
19
20 // (ii) Working Period of Lift , tw
21     tw=H/V;           //s
22
23 // (iii) Ideal Period of Lift , ti
24     ti=t-tw;         //s
25
26 //Results
27     printf(" (i) Power required to drive the
28           Lift , P=%0.f kW \n",P)
29     printf(" (ii) Working Period of Lift ,
30           tw =%0.f s \n",tw)
31     printf(" (iii) Ideal Period of Lift ,
32           ti =%0.f s \n",ti)

```

Scilab code Exa 16.17 To Find the Efficiency of Hydraulic Crane

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 16– Hydraulic Power and Its Transmissions
3 //Example 16.17
4 //To Find the Efficiency of Hydraulic Crane.
5
6     clc
7     clear
8
9 //Given Data:–
10     V=340;           //Volume of water utilized ,
11                       litres
12     p=50;           //Pressure Intensity , bar
13     W=125;         //Load Lift , kN
14     l=10;          //Displacement of Weight , m
15

```

```

16 //Computations:-
17     Energy=p*10^5*V/1000;           //Energy
        Supplied to Crane, J
18     Work=W*1000*1;                 //Work done by
        crane in lifting load, J
19     eta=Work/Energy*100;           //Efficiency
        In Percentage
20
21 //Result:-
22     printf("Efficiency of Hydraulic Crane, eta=
        %.2f Percent\n",eta)         //The answer
        vary due to round off error

```

Scilab code Exa 16.18 To Find i The Load Lifted by Crane ii The Quantity of Water

```

1 //Fluid Systyems – By Shiv Kumar
2 //Chapter 16– Hydraulic Power and Its Transmission
3 //Example 16.18
4 //To Find (i)The Load Lifted by Crane (
    ii)The Quantity of Water needed to Lift the Load.
5
6     clc
7     clear
8
9 //Given Data:-
10    d=200;           //Diameter of Ram, mm
11    p=7.5;           //Pressure of Water Supplied,
        MPa
12    VR=6;           //Velocity Ratio
13    eta=50/100;     //Efficiency of Crane
14    h=10;           //Height through which water is
        to be lifted, m]
15
16 //Computations:-
17    d=d/1000;       //m

```

```

18     p=p*10^6;           //Pa
19
20     Fp=(%pi/4)*d^2*p;   //Pressure Force
    Exerted on Ram, N (answer vary due to
    value of %pi)
21     W=Fp*eta/VR;       //Load Lifted by Crane
    , N
22     Vw=(%pi/4)*d^2*h/VR*1000; //
    Quantity of Water needed, Litres
23
24 //Results:-
25     printf(" (i)The Load Lifted by Crane, W=%0.f N
    \n",W) //The answer provided in
    textbook is wrong
26     printf(" (ii)The Quantity of Water needed to
    Lift the Load by 10 m =%0.2f Litres \n",Vw)
    //The answer vary due to round off
    error

```

Chapter 17

Dimensional and Model Analysis

Scilab code Exa 17.1 Theoretical Problem to Check Dimensions

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.1
4 //Theoretical Problem to Check Dimensions.
```

Scilab code Exa 17.2 Theoretical Problem to Obtain Expression for Velocity of Prop

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.2
4 //Theoretical Problem to Obtain Expression
  for Velocity of Propagation of Wave
```

Scilab code Exa 17.3 Theoretical Problem

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.3
4 //Theoretical Problem.
```

Scilab code Exa 17.4 Theoretical Problem to Find expression for Drag Force

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.4
4 //Theoretical Problem to Find expression for
  Drag Force.
```

Scilab code Exa 17.5 Theoretical Problem

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.5
4 //Theoretical Problem .
```

Scilab code Exa 17.6 Theoretical Problem

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.6
4 //Theoretical Problem .
```

Scilab code Exa 17.7 Theoretical Problem

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.7
4 //Theoretical Problem.
```

Scilab code Exa 17.8 Theoretical Problem

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.8
4 //Theoretical Problem.
```

Scilab code Exa 17.9 Theoretical Problem to Find Expression for Force exerted by a

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.9
4 //Theoretical Problem to Find Expression for
  Force exerted by a Flowing Liquid.
```

Scilab code Exa 17.10 Theoretical Problem

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.10
4 //Theoretical Problem (Same as 17.9).
```

Scilab code Exa 17.11 Theoretical Problem

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.11
4 //Theoretical Problem .
```

Scilab code Exa 17.12 Theoretical Problem

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.12
4 //Theoretical Problem to Find Expression for
   Delta(p).
```

Scilab code Exa 17.13 Theoretical Problem

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.13
4 //Theoretical Problem .
```

Scilab code Exa 17.14 Theoretical Problem to obtain Expression for Drag Force

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.14
```

```
4 //Theoretical Problem to obtain Expression  
   for Drag Force.
```

Scilab code Exa 17.15 Theoretical Problem to Develop an Expression for the Thrust

```
1 //Fluid Systems – By Shiv Kumar  
2 //Chapter 17– Dimensional and Model Analysis  
3 //Example 17.15  
4 //Theoretical Problem to Develop an  
   Expression for the Thrust developed by a  
   Propeller.
```

Scilab code Exa 17.16 Theoretical Problem

```
1 //Fluid Systems – By Shiv Kumar  
2 //Chapter 17– Dimensional and Model Analysis  
3 //Example 17.16  
4 //Theoretical Problem.
```

Scilab code Exa 17.17 To Find the Velocity of Oil flowing in the Pipe for the cond

```
1 //Fluid Systems – By Shiv Kumar  
2 //Chapter 17– Dimensional and Model Analysis  
3 //Example 17.17  
4 //To Find the Velocity of Oil flowing in the Pipe  
   for the condition of Dynamic Similarity.  
5  
6     clc  
7     clear  
8
```

```

9 //Given:-
10 //For Model ( Working Fluid is Oil),
11     Dm=80; //Diameter, mm
12     nu_m=0.03; //Kinematic Viscosity of
        Oil, Stoke
13
14 //For Prototype ( Working Fluid is Water),
15     Dp=200; //Diameter, mm
16     Vp=3.5; //Velocity of Water in the
        Pipe, m/s
17     nu_p=0.01; //Kinematic Viscosity of
        Water, Stoke
18
19 //Computations:-
20 //From Reynold's Law of Similarity,
21     Vm=Vp*(Dp/Dm)*(nu_m/nu_p); //
        Velocity of Oil, m/s
22
23 //Results:-
24     printf("The Velocity of Oil , Vm=%0.2 f m/s\n
        ",Vm)

```

Scilab code Exa 17.18 To Find the Velocity and Rate of Flow in the Model

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.18
4 //To Find the Velocity and Rate of Flow in the Model
5
6     clc
7     clear
8
9 //Given:-
10 //For Model ( Working Fluid is Water),

```

```

11         Dm=150;           //Diameter of Pipe, mm
12         mu_m=0.01;        //Viscosity of Water,
                             Poise
13
14         //For Prototype ( Working Fluid is Oil),
15         Dp=1.5;           //Diameter, m
16         Sp=0.9;           //Specific Gravity of Oil
17         mu_p=3*10^-2;     //Viscosity of Oil,
                             Poise
18         Qp=3000;          //Discharge of Oil,
                             Litres/sec
19
20         //Data Required:-
21         rho_m=1000;        //Density of Water, Kg
                             /m^3
22
23
24         //Computations:-
25         Dm=Dm/1000;       //m
26         Qp=Qp/1000;       //m^3/s
27         Ap=(%pi/4)*Dp^2;   //m^2
28         Am= (%pi/4)*Dm^2 ; //m^2
29         Vp=Qp/Ap;         //m/s
30         rho_p=Sp*rho_m;    //Kg/m^3
31
32         //From Reynold's Law of Similarity ,
33         Vm=Vp*(Dp/Dm)*(mu_m/mu_p)*(rho_p/
                             rho_m); //Velocity of Water
                             in Model, m/s
34         Qm=Am*Vm*1000;     //Rate of
                             Flow in Model, Litres/sec
35
36         //Results:-
37         printf("The Velocity in the Model, Vm=%0.3f
                             m/s\n",Vm) //The Answer Vary due to
                             Round off Error
38         printf("The Rate of Flow in the Model, Qm=%
                             .2f Litres/sec\n",Qm) //The

```

Scilab code Exa 17.19 To Find the Speed of Air in Wind Tunnel and Determine the Th

```
1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.19
4 //To Find the Speed of Air in Wind Tunnel and
   Determine the The Ratio of Drag(Resistance)
   between the Model and its Prototype.
5
6     clc
7     clear
8
9 //Given:–
10         Lr=30;           //Scale Ratio (Lp/Lm)
11         //For Model ( Working Fluid is Air),
12             nu_m=0.016;           //Kinematic Viscosity
               of Air, Stoke
13             rho_m=1.24;           //Density of Air, Kg/m
               ^3
14
15         //For Prototype ( Working Fluid is Sea Water),
16             Vp=10;           //Speed of Sub–marine (
               Prototype), m/s
17             nu_p=0.012;           //Kinematic Viscosity of
               Sea Water, Stoke
18             rho_p=1030;           //Density of Sea Water,
               Kg/m^3
19
20 //Computations:–
21         //From Reynold’s Law of Similarity ,
22             Vm=Vp*(nu_m/nu_p)*Lr;           //Velocity
               of Air, m/s
23
```



```

24         Fp_by_Fm=(rho_p/rho_m)*Lr^2*(Vp/Vm)
           ^2;           //Ratio of Drag Force (
                       Resistance)
25
26
27 //Results:-
28     printf("The Speed of Air in Wind Tunnel ,
           Vm=%0. f m/s\n",Vm)
29     printf("The Ratio of Drag Force (Resistance
           ), Fp/Fm=%0.3 f \n",Fp_by_Fm)

```

Scilab code Exa 17.20 To Find the Discharge and the Velocity over the Prototype

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.20
4 //To Find the Discharge and the Velocity over the
   Prototype.
5
6     clc
7     clear
8
9 //Given Data:-
10     //For Model,
11     Qm=3; //Discharge over the Model, m^3/
           s
12     Vm=1.5; //Velocity of Flow over the
           Model, m/s
13     Lr=40; //Scale Ratio (Lp/Lm)
14
15
16 //Computations:-
17     //By Froude’s Law of Similarity ,
18     Vp=Vm*Lr^(1/2); //Velocity of
           Flow over the Prototype, m/s

```

```

19         Qp=Lr^2*(Vp/Vm)*Qm;           //Discharge
           over the Prototype , m^/s
20
21
22 //Results:-
23     printf("The Velocity over the Prototype , Vp=%
           .2 f m/s \n",Vp)           //The Answer Vary due
           to Round off Error.
24     printf("The Discharge over the Prototype , Qp=
           %. f m^3/s \n",Qp)           //The Answer
           provided in the Textbook is Wrong.

```

Scilab code Exa 17.21 To Find the Ship Velocity and Propulsive Force in the Protot

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.21
4 //To Find the Ship Velocity and Propulsive Force in
   the Prototype.
5
6     clc
7     clear
8
9 //Given Data:-
10    //For Model ,
11        Lm=1;           //Length of Model, m
12        Vm=0.7;        //Speed in the Model, m/s
13        Fm=5;          //Force in the Model, N
14
15    //For Prototype ,
16        Lp=50;          //Length of Prototype , m
17
18
19 //Computations:-
20    //By Froude’s Law of Similarity ,

```

```

21         Vp=Vm*(Lp/Lm)^(1/2);           //Velocity
           of the Prototype(Ship), m/s
22         Fp=Fm*(Lp/Lm)^3/1000;         //
           Propulsive Force in the Prototype,
           kN
23
24
25 //Results:-
26     printf("The Ship(Prototype) Velocity , Vp=%0.2
           f m/s \n",Vp)
27     printf("The Propulsive Force in the Prototype
           , Fp=%0.f kN \n",Fp)

```

Scilab code Exa 17.22 To Determine for the Model i The Size and the Velocity of Wa

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.22
4 //To Determine for the Model:      (i) The Size and
           the Velocity of Waves      (ii)The Tidal Period
5
6     clc
7     clear
8
9 //Given Data:-
10         Lr=200;           //Scale Ratio
11         //For Prototype ,
12         Ap=20;           //Amplitude of Waves, m
13         Vp=10;           //Velocity , m/s
14         Tp=12;           //Time Period , hrs.
15
16 //Computations:-
17         //By Froude’s Law of Similarity ,
18         Vm=Vp/Lr^(1/2);           //Velocity of
           Wave in the Model, m/s

```

```

19         Am=Ap/Lr;           //Amplitude of waves
           in the Model, m
20         Tm=Tp*60/Lr^(1/2); //Tidal Period
           in the Model, min.
21
22
23 //Results:-
24         printf("(i)For the Model:\n      Velocity of
           Wave, Vm=%0.3 f m/s\n      Size(Amplitude) of
           Wave, Am=%0.1 f m\n",Vm,Am)
25         printf("(ii)The Tidal Period in the Model, Tm
           =%0.2 f min. \n",Tm)

```

Scilab code Exa 17.23 To Find the Velocity of the Prototype and Force Required to

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.23
4 //To Find the Velocity of the Prototype and Force
   Required to Propel the Prototypte.
5
6     clc
7     clear
8
9 //Given Data:-
10        Lr=40;           //Scale Ratio (Lp/Lm)
11        //For Model,
12        Vm=2;           //Velocity for the Model, m/s
13        Fm=0.5;        //Propulsive Force in Model
           , N
14        //For Prototype,
15        Lp=45;         //m
16
17
18 //Computations:-

```

```

19         //By Froude's Law of Similarity ,
20         Vp=Vm*Lr^(1/2);           //Velocity for
           the Prototype , m/s
21         Fp=Fm*Lr^3;           //Force Required to
           Propel the Prototytp , N
22
23
24 //Results:-
25     printf("The Velocity of the Prototype , Vp=%.2
           f m/s \n",Vp)           //The Answer vary due
           to Round off Error
26     printf("The Force Required to Propel the
           Prototytp , Fp=%.f N \n",Fp)

```

Scilab code Exa 17.24 To Find the Prototype to Model Scale Ratios for i Velocity i

```

1 //Fluid Systems – By Shiv Kumar
2 //Chapter 17– Dimensional and Model Analysis
3 //Example 17.24
4 //To Find the Prototype to Model Scale Ratios for :
   (i) Velocity      (ii) Time      (iii) Acceleration
   (iv) Force .     and Wave Height and Time
   taken for Model.
5
6     clc
7     clear
8
9 //Given Data:-
10        Lr=50;           //Scale Ratio (Lp/Lm)
11        //For Prototype ,
12        Hp=1.5;         //m
13        Tp=25;         //Seconds (s)
14
15 //Computations:-
16        Vr=Lr^(1/2);           //Velocity Ratio

```

```

17         Tr=Lr^(1/2);           //Time Ratio
18         ar=Vr/Tr;             //Acceleration Ratio
19         Fr=Lr^3;              //Force Ratio
20
21         Hm=Hp/Lr;             //m
22         Tm=Tp/Tr;             //Seconds(s)
23
24
25 //Results:-
26         printf("(i) Velocity Ratio , Vr=%0.2f\n (ii) Time
           Ratio , Tr=%0.2f \n (iii) Acceleration Ratio
           , ar=%0.f \n(iv) Force Ratio , Fr=%0.f\n\n ",
           Vr,Tr,ar,Fr)
27         printf("Wave Height in the Model, Hm=%0.2f m\n
           ",Hm)
28         printf("Time taken in the Model, Tm=%0.2f s",
           Tm)           //The Answer Vary due to Round off
                           Error

```
