1. Routine Function

```
function f = ConstructDisk (x),
R = [0.0 6.0 5.0 3.5 2.0 1.0]; %inches
L = [3 3 3 3 3 3]; %inches
N = 10000; %rpm
V = 1; %velocity, inch per sec
nu = 0.3; %poisson ratio (v)
rho = 0.284; %density
P(2)=0.0; %pressure at the outermost ring surface ,psi
P(6)=1001; %internal pressure at the bore, in this case P6=Pm
P(1)=0;
for n=1:5,
    B(1,n) = (2*(R(n)/R(n+1))^2)/((R(n)/R(n+1))^2-1);
end
%[A,B,C,D,K,Q,U] = basic_calc(R,L,N,V); %calculation of
A,B,C,D,K,Q,U using basic_calc function
for n=2:4,
    %An
    A(1,n) = (((3+nu)*rho*10^4)/4)*((R(n)/R(1,2))^2-
(R(n+2)/R(1,2))^2);
    %Bn
    %B(1,n) = (2*(R(n)/R(n+1))^2)/((R(n)/R(n+1))^2-1);
    %Cn
    C(1,n) = 2/((R(n+1)/R(n+2))^2-1);
    %Dn
    D(1,n) = (((1-nu)+(1+nu)*(R(n)/R(n+1))^2)/((R(n)/R(n+1))^2-
1))+(L(n)/L(n+1))*(((1+nu)+(1-
nu)*(R(n+1)/R(n+2))^2)/((R(n+1)/R(n+2))^2-1));
    %Kn
    K(1,n) = A(1,n)/C(1,n);
    %Qn
    Q(1,n) = (B(1,n)/C(1,n))*(L(n-1))/L(n);
    %Un
    U(1,n) = D(1,n)/C(1,n);
end
```

```
P3_g =(200-rand(1,2)*(200-100)); %initial guess for P3, 2 random
numbers between 100-200
for n=1:2,
    P4_g=K(2)*V^2-Q(2)*P(2)+U(2)*P3_g(1,:);       %calculation for
P6
    P5_g=K(3)*V^2-Q(3)*P3_g(1,:)+U(3)*P4_g;     %using initial
guess of P3
    P6_g=K(4)*V^2-Q(4)*P4_g+U(4)*P5_g;          %to obtain linear
equation for interpolation
end
%interpolation, using actual value of P6 to obtain correct value
of P3
P(3) = (((P(6)-P6_g(1,1))*(P3_g(1,2)-P3_g(1,1)))/(P6_g(1,2)-
P6_g(1,1)))+P3_g(1,1);
%P(3) = interp1(P6_g,P3_g,P(6),'linear','extrap');
%calculation of pressure for each interface
P(4) = K(1,2)*V^2-Q(1,2)*P(2)+U(1,2)*P(3);
P(5) = K(1,3)*V^2-Q(1,3)*P(3)+U(1,3)*P(4);
P(6) = K(1,4)*V^2-Q(1,4)*P(4)+U(1,4)*P(5);
%P = [P1, P2, P3, P4, P5, P6],
%radial stress calculation for each interface
%[radial_stress]= radial_calc(P,L);
%disp('radial stress for each interface, sigma_r(1-5)');
%[radial_stress],
for n=2:5,
    %En
    E(1,n) = 1/((R(1,n)/R(1,n+1))^2-1);
    %Fn
    F(1,n) = (((((3+nu)*rho)*10^4)/4)*(R(1,n)/R(1,2))^2)+(((1-
nu)*rho*10^4)/4)*(R(1,n+1)/R(1,2))^2;
    %tangential stress (n)
    tangential_stress(1,n-1)=-
(B(1,n)*(L(1,n+1)/L(1,n))*P(1,n))+((E(1,n)+(B(1,n)/2)-
nu/2*(L(1,n)/L(1,n+1)))*P(1,n+1))+F(1,n)*V^2;
end
    %Radial stress (n)
for n=2:5,
    radial_stress(1,n-1) = -((1+(L(1,n)/L(1,n+1)))*P(1,n+1))/2;
```

```
end
    %Objective_function to shear_stress (n)
for n=1:4,
    shear_stress(1,n)= (tangential_stress(1,n)-
radial_stress(1,n))/2;
end
    %Objective_function to von-mises_stress (n)
for n=1:4,
von_misses(1,n)= sqrt((tangential_stress(1,n))^2+
(radial_stress(1,n))^2-tangential_stress(1,n)*radial_stress(1,n));
end
%f=mean(tangential_stress);
%tangential stress calculation for each interface
%[tangential_stress]= tangential_calc (B, L, P, nu, V, R, rho);
%disp('tangential stress for each interface, sigma_t(1-5)');
%[tangential_stress],
```

2. *Routine* Optimasi untuk variabel L

```
clc
clear all
warning off
x0 = [1.0 2.5],       % Make a starting guess at solution
f = ConstructDisk (x0),
options = optimset ('Display', 'iter', 'PlotFcns', @optimplotfval,
'MaxFunEvals', 10000);
[x,fval] = fminimax (@ConstructDisk, x0, [], [], [], [], [0.6
0.6], [3 3], @constraint, options),
```

3. *Routine* Optimasi multivariabel

```
clc
clear all
warning off
x0 = [5 3.5 2 2 3 3 2],       % Make a starting guess at solution
f = ConstructDisk (x0),
A= [1 0 0 0 0 0 0;-1 1 0 0 0 0 0;0 -1 1 0 0 0 0;0 0 -1 0 0 0 0], %
Contrains
```

```
b= [5.9;-0.1;-0.1;-1.1],
options = optimset ('Display', 'iter', 'PlotFcns', @optimplotfval,
'MaxFunEvals', 10000);
[x,fval] = fminimax (@ConstructDisk, x0, A, b, [], [], [-Inf -Inf
-Inf 0.6 0.6 0.6 0.6], [Inf Inf Inf 3 3 3 3], @constraint,
options),
```

4. *Routine* mencari nilai *Objective function*

```
clc
clear all
x=[0.1:0.25:9.1]; % Make a starting guess at 1 value
y= 9.1;           % Make a starting guess at 2 value

for n=1:37,       % Mencari nilai Objective Function disetiap
titik
[f(n)]=ConstructDisk (x(n),y);
end
```

5. *Routine Plot* Grafik Isomerit Hasil optimasi

```
clc
clear all
x=[0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1
:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3
.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1
:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3
.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1
:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3.5;0.1:0.1:3
.5;0.1:0.1:3.5;0.1:0.1:3.5];
y=x';
z=[7674.223419   8852.107749  9276.217117  9453.501938  9523.502129
9539.613487  9526.3641      9496.406157  9456.801099  9411.714994
9363.704628  9314.382724  9264.78441    9215.579543  9167.200875
9119.924066  9073.919073  9029.283927  8986.067376  8944.284316
8903.926455  8864.969747  8827.379642  8791.114797  8756.129717
8722.376641  8689.806877  8658.371749  8628.023259  8598.714543
8570.400174 8543.036359 8516.581055 8490.994022 8466.236839
```

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2038.299118 2052.021338 2064.973303 2077.281072 2089.040484
2100.32587 2111.195907 2121.697651 2131.869382 2141.742649
2151.343757 2160.694885 2169.814918 2178.720086 2187.424457
2195.940324 2204.278509 2212.448601 2220.459159 2228.31786
2236.031635 2243.606771 2251.048999 2258.363569 2265.555308
1665.716983 1768.381131 1828.004659 1868.857684 1899.802226
1924.846259 1946.067913 1964.653017 1981.328212 1996.564095
2010.679261 2023.897412 2036.380506 2048.248903 2059.594102
2070.487055 2080.983763 2091.129129 2100.959671 2110.50548
2119.791641 2128.839295 2137.66644 2146.28854 2154.718994

2162.969508 2171.050382 2178.970744 2186.738736 2194.36166
2201.846108 2209.198055 2216.422951 2223.525784 2230.511141
1654.242732 1752.413921 1809.499277 1848.653829 1878.33964
1902.385718 1922.77805 1940.650124 1956.696611 1971.367439
1984.967223 1997.709847 2009.750155 2021.203211 2032.156478
2042.677772 2052.820607 2062.627884 2072.134489 2081.369156
2090.355837 2099.114712 2107.662955 2116.015318 2124.184582
2132.181905 2140.017108 2147.698888 2155.234999 2162.632399
2169.897361 2177.035577 2184.052232 2190.952071 2197.739459
1643.572832 1737.55889 1792.275298 1829.841948 1858.349144
1881.459421 1901.073002 1918.274655 1933.729276 1947.867545
1960.981054 1973.274544 1984.896232 1995.956251 2006.538306
2016.707291 2026.514405 2036.000689 2045.199504 2054.138327
2062.840054 2071.32397 2079.606485 2087.701689 2095.621785
2103.377427 2110.977986 2118.43176 2125.746146 2132.927778
2139.982637 2146.916146 2153.733247 2160.438462 2167.035947
1633.629178 1723.709033 1776.210254 1812.289716 1839.69144
1861.922781 1880.803988 1897.37437 1912.271047 1925.906735
1938.560873 1950.429668 1961.655152 1972.342857 1982.572982
1992.407693 2001.896034 2011.077305 2019.983451 2028.640774
2037.071186 2045.293139 2053.32233 2061.172232 2068.854512
2076.379352 2083.755706 2090.9915 2098.093798 2105.068932
2111.922613 2118.660014 2125.285849 2131.804432 2138.219726
1624.343309 1710.770427 1761.196553 1795.880795 1822.243981
1843.648537 1861.839981 1877.81514 1892.185162 1905.34597
1917.565639 1929.032397 1939.882495 1950.21716 1960.113316
1969.630579 1978.815977 1987.707186 1996.334826 2004.724102
2012.896008 2020.868217 2028.655761 2036.271538 2043.726715
2051.031033 2058.193056 2065.220365 2072.119711 2078.897149
2085.558132 2092.107604 2098.550068 2104.88964 2111.130105
1615.654975 1698.660306 1747.139298 1780.512504 1805.898545
1826.524242 1844.065157 1859.47834 1873.350619 1886.062185
1897.870471 1908.956229 1919.450296 1929.44987 1939.028803
1948.244327 1957.14158 1965.756721 1974.119128 1982.25298
1990.178412 1997.912369 2005.469261 2012.861449 2020.09963
2027.193135 2034.150165 2040.977976 2047.68303 2054.271118
2060.747458 2067.116777 2073.383378 2079.551199 2085.623855

```
1607.510946   1687.305463   1733.954482   1766.093887   1790.559216
1810.450185   1827.376765   1842.258695   1855.659988   1867.946078
1879.364411   1890.088728   1900.244784   1909.925995   1919.203336
1928.131801   1936.754756   1945.106936   1953.216557   1961.106835
1968.7971      1976.303617  1983.640211  1990.81874    1997.849463
2004.741328   2011.502193   2018.139012   2024.657975   2031.064628
2037.363968 2043.560519 2049.6584   2055.661377 2061.572909
1599.864028   1676.640914   1721.567478   1752.544095   1776.14069
1795.33765    1811.683342   1826.062457   1839.01757    1850.900248
1861.948552   1872.329633   1882.164473   1891.542934   1900.533287
1909.188424   1917.550048   1925.651554   1933.520067   1941.177903
1948.643633   1955.932885   1963.058935   1970.03317    1976.865438
1983.564326   1990.137373   1996.591249   2002.931889   2009.164611
2015.294203 2021.324999 2027.260946 2033.10565   2038.862422];   %
Nilai Objective Function disetiap titik

contour(x,y,z)
hold on
aa=[0 3.5];
bb=[3 3];                    % Plot garis grafik upper boundary
cc=[0.6 0.6];                % Plot garis grafik lower boundary
plot(bb,aa,'-.k','LineWidth',1.5);
plot(cc,aa,'-.k','LineWidth',1.5);
plot(aa,bb,'-.k','LineWidth',1.5);
plot(aa,cc,'-.k','LineWidth',1.5);
hold off
hold on
a=[2.75 0.6 0.88 1.02 ];     % Nilai variabel Tebakan 1 optimasi
b=[2.75 3 3 3];
plot (a,b,'--*');            %  Plot  garis  grafik  Tebakan  1
optimasi
c=[2 1.03 1.02];             % Nilai variabel Tebakan 2 optimasi
d=[2 3 3];
plot (c,d,'--*')             %  Plot  garis  grafik  Tebakan  2
optimasi
e=[1 0.69 0.93 1.02 ];       % Nilai variabel Tebakan 3 optimasi
f=[1 3 3 3];
```

```
plot (e,f,'--*')                % Plot garis grafik Tebakan 3
optimasi
```

Table B.1 Room-Temperature Density Values for Various Engineering Materials

Material	Density g/cm^3	Density $lb_m/in.^3$
METALS AND METAL ALLOYS		
Plain Carbon and Low Alloy Steels		
Steel alloy A36	7.85	0.283
Steel alloy 1020	7.85	0.283
Steel alloy 1040	7.85	0.283
Steel alloy 4140	7.85	0.283
Steel alloy 4340	7.85	0.283
Stainless Steels		
Stainless alloy 304	8.00	0.289
Stainless alloy 316	8.00	0.289

Table B.3 Room-Temperature Poisson's Ratio Values for Various Engineering Materials

Material	Poisson's Ratio
METALS AND METAL ALLOYS	
Plain Carbon and Low Alloy Steels	
Steel alloy A36	0.30
Steel alloy 1020	0.30
Steel alloy 1040	0.30
Steel alloy 4140	0.30
Steel alloy 4340	0.30
Stainless Steels	
Stainless alloy 304	0.30
Stainless alloy 316	0.30
Stainless alloy 405	0.30
Stainless alloy 440A	0.30
Stainless alloy 17-7PH	0.30
Cast Irons	
Gray irons	
• Grade G1800	0.26
• Grade G3000	0.26
• Grade G4000	0.26
Ductile irons	
• Grade 60-40-18	0.29
• Grade 80-55-06	0.31
• Grade 120-90-02	0.28
Aluminum Alloys	
Alloy 1100	0.33
Alloy 2024	0.33
Alloy 6061	0.33
Alloy 7075	0.33
Alloy 356.0	0.33
Copper Alloys	
C11000 (electrolytic tough pitch)	0.33
C17200 (beryllium–copper)	0.30
C26000 (cartridge brass)	0.35
C36000 (free-cutting brass)	0.34
Refractory Metals	
Molybdenum (commercially pure)	0.32
Tantalum (commercially pure)	0.35
Tungsten (commercially pure)	0.28
Miscellaneous Nonferrous Alloys	
Nickel 200	0.31
Inconel 625	0.31
Monel 400	0.32
Chemical lead	0.44
Tin (commercially pure)	0.33
Zinc (commercially pure)	0.25
Zirconium, reactor grade 702	0.35
GRAPHITE, CERAMICS, AND SEMICONDUCTING MATERIALS	
Aluminum oxide	
• 99.9% pure	0.22
• 96%	0.21
• 90%	0.22
Concrete	0.20
Diamond	
• Natural	0.10–0.30
• Synthetic	0.20
Gallium arsenide	
• (100) orientation	0.30
Glass, borosilicate (Pyrex)	0.20
Glass, soda–lime	0.23
Glass ceramic (Pyroceram)	0.25
Silica, fused	0.17
Silicon	
• (100) orientation	0.28
• (111) orientation	0.36
Silicon carbide	
• Hot pressed	0.17
• Sintered	0.16

Table B.4 Typical Room-Temperature Yield Strength, Tensile Strength, and Ductility (Percent Elongation) Values for Various Engineering Materials

Material/Condition	*Yield Strength (MPa [ksi])*	*Tensile Strength (MPa [ksi])*	*Percent Elongation*
METALS AND METAL ALLOYS			
Plain Carbon and Low Alloy Steels			
Steel alloy A36			
• Hot rolled	220–250 (32–36)	400–500 (58–72.5)	23
Steel alloy 1020			
• Hot rolled	210 (30) (min)	380 (55) (min)	25 (min)
• Cold drawn	350 (51) (min)	420 (61) (min)	15 (min)
• Annealed (@ 870°C)	295 (42.8)	395 (57.3)	36.5
• Normalized (@ 925°C)	345 (50.3)	440 (64)	38.5
Steel alloy 1040			
• Hot rolled	290 (42) (min)	520 (76) (min)	18 (min)
• Cold drawn	490 (71) (min)	590 (85) (min)	12 (min)
• Annealed (@ 785°C)	355 (51.3)	520 (75.3)	30.2
• Normalized (@ 900°C)	375 (54.3)	590 (85)	28.0
Steel alloy 4140			
• Annealed (@ 815°C)	417 (60.5)	655 (95)	25.7
• Normalized (@ 870°C)	655 (95)	1020 (148)	17.7
• Oil-quenched and tempered (@ 315°C)	1570 (228)	1720 (250)	11.5
Steel alloy 4340			
• Annealed (@ 810°C)	472 (68.5)	745 (108)	22
• Normalized (@ 870°C)	862 (125)	1280 (185.5)	12.2
• Oil-quenched and tempered (@ 315°C)	1620 (235)	1760 (255)	12
Stainless Steels			
Stainless alloy 304			
• Hot finished and annealed	205 (30) (min)	515 (75) (min)	40 (min)
• Cold worked ($\frac{1}{4}$ hard)	515 (75) (min)	860 (125) (min)	10 (min)
Stainless alloy 316			
• Hot finished and annealed	205 (30) (min)	515 (75) (min)	40 (min)
• Cold drawn and annealed	310 (45) (min)	620 (90) (min)	30 (min)
Stainless alloy 405			
• Annealed	170 (25)	415 (60)	20