[HEAT TRANSFER REPORT]

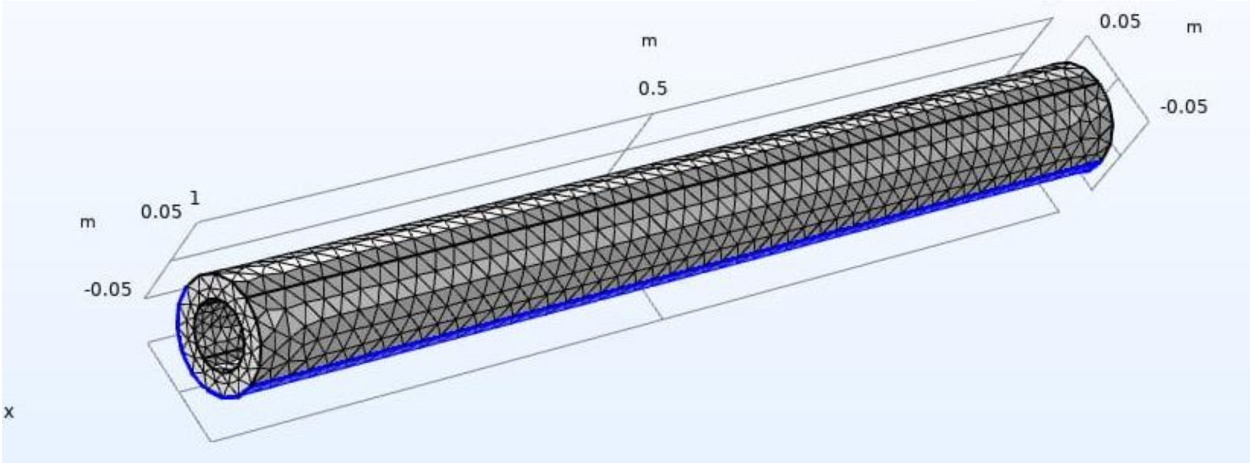
[Mechanical Department]

Case One:

A truck cartage that has a top surface of length (L) 8m and width (W) 2.5m, is travelling on the highway. The top surface of the cartage is subjected to 1000 W/m2 solar radiation and the surface absorptivity is 20%. The ambient air is 20°C and the radiation from the cartage top surface is neglected (heat transferred from the surface is assumed to be only by convection to ambient air).

Case Two:

A pipe of diameter 6 cm and a length of 1 m is carrying boiling water, it's needed to use an insulating material to reduce the heat loss from the pipe. If the pipe is surrounded by air at 25℃ with a heat transfer coefficient of 5 $W/m2$. ℃

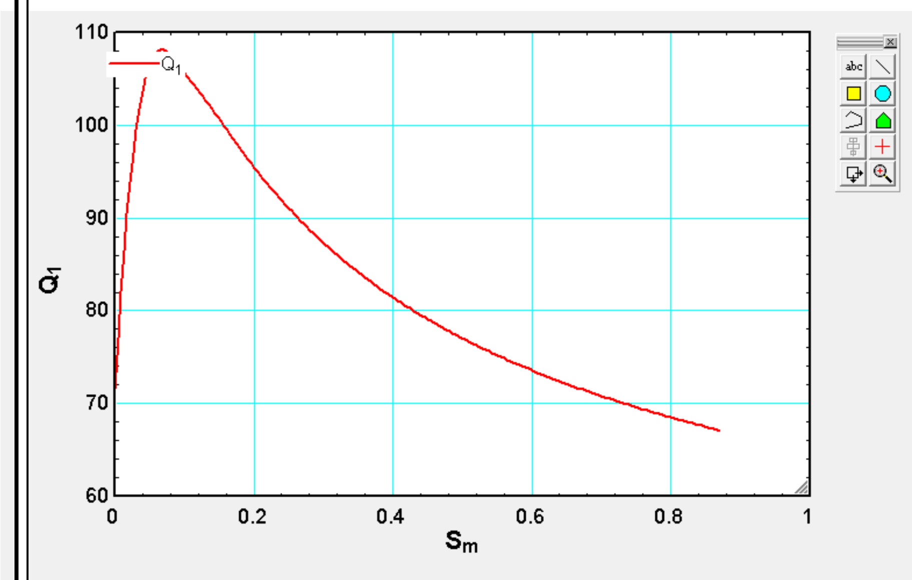


EES

1:

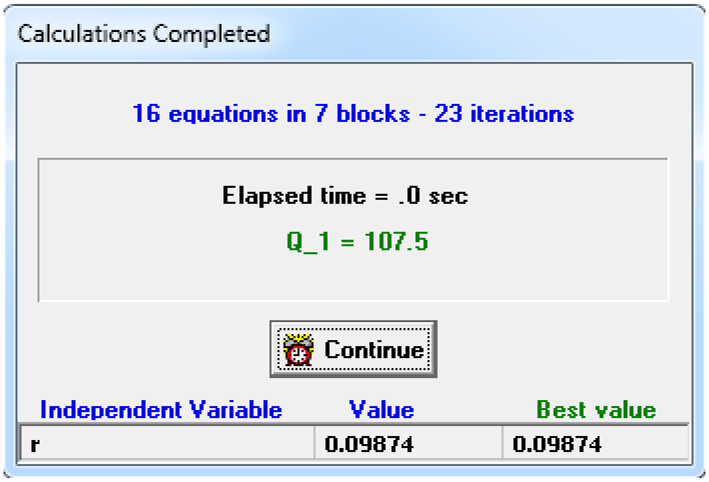
"For Material A"
r_p=.03[m]
L=1[m]
A=3.18*L*r*2
h=5[w/m^2.c]
T_surr=25[c]
T_1=100[c]
K_1=.5[w/m.c]
K_2=.4[w/m.c]
K_3=.3[w/m.c]
K_4=.2[w/m.c]
K_5=.05[w/m.c]
R_CONV=1/(h*A)
R_INS=**ln**(r/r_p)/(2*3.14*k_1*L)
R_TOT=R_INS+R_CONV
Q_1=(T_1-T_surr)/R_TOT
S_m=r-r_p

Graph



1..20	r	S_m	Q_1
Run 1	0.03	0	71.55
Run 2	0.07579	0.04579	105.6
Run 3	0.1216	0.09158	106.5
Run 4	0.1674	0.1374	102
Run 5	0.2132	0.1832	97.15
Run 6	0.2589	0.2289	92.84
Run 7	0.3047	0.2747	89.13
Run 8	0.3505	0.3205	85.95
Run 9	0.3963	0.3663	83.21
Run 10	0.4421	0.4121	80.83
Run 11	0.4879	0.4579	78.73
Run 12	0.5337	0.5037	76.87
Run 13	0.5795	0.5495	75.21
Run 14	0.6253	0.5953	73.71
Run 15	0.6711	0.6411	72.35
Run 16	0.7168	0.6868	71.12
Run 17	0.7626	0.7326	69.98
Run 18	0.8084	0.7784	68.94
Run 19	0.8542	0.8242	67.97
Run 20	0.9	0.87	67.08

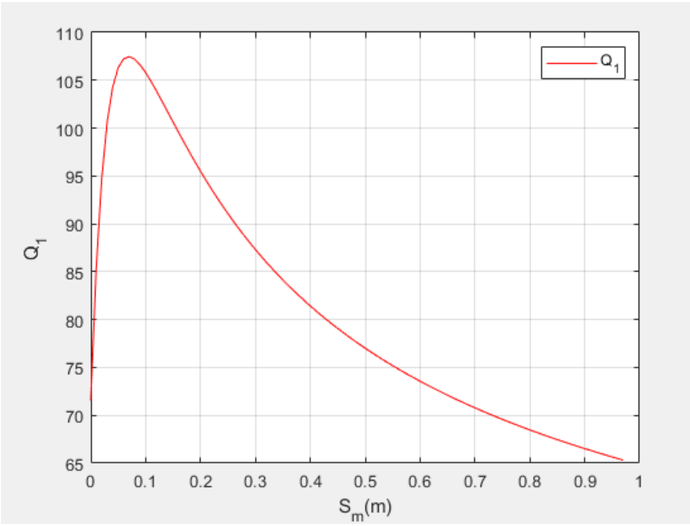
Critical Radius of insulation(rc):



Matlab

```
clc,clear
rp=.03;k1=.5;Tamb=25;T=100;h=5;L=1;
r=.03:.01:1;
A=3.18*L*r*2;
R_CONV=1./(5*A);
R_INS=log(r/rp)/(2*3.14*k1*L);
R_TOT=R_INS+R_CONV;
Q_1=(T-Tamb)./R_TOT;
S_m=(r-rp);
plot(S_m,Q_1,'r')
legend('Q_1')
grid on
xlabel('S_m(m)')
ylabel('Q_1')
```

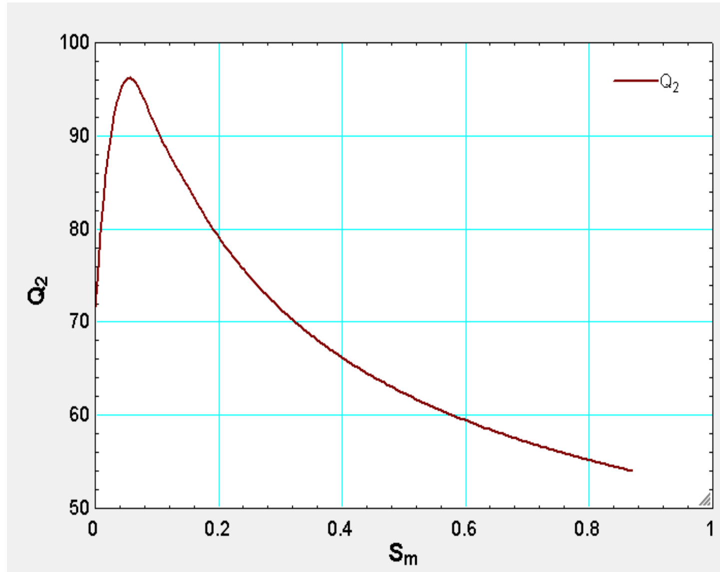
Graph



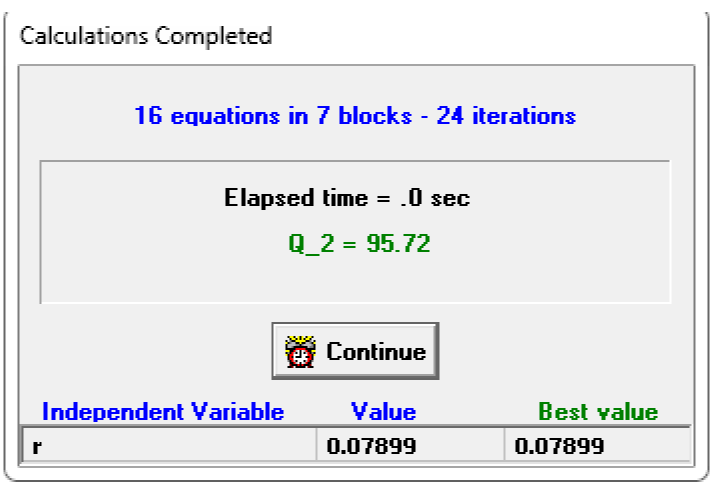
"For Material B"
r_p=.03[m]
L=1[m]
A=3.18*L*r*2
h=5[w/m^2.c]
T_surr=25[c]
T_1=100[c]
K_1=.5[w/m.c]
K_2=.4[w/m.c]
K_3=.3[w/m.c]
K_4=.2[w/m.c]
K_5=.05[w/m.c]
R_CONV=1/(h*A)
R_INS=**ln**(r/r_p)/(2*3.14*k_2*L)
R_TOT=R_INS+R_CONV
Q_2=(T_1-T_surr)/R_TOT
S_m=r-r_p

Graph

1..20	r	S_m	Q_2
Run 1	0.03	0	71.55
Run 2	0.07579	0.04579	95.68
Run 3	0.1216	0.09158	91.94
Run 4	0.1674	0.1374	85.99
Run 5	0.2132	0.1832	80.81
Run 6	0.2589	0.2289	76.57
Run 7	0.3047	0.2747	73.09
Run 8	0.3505	0.3205	70.2
Run 9	0.3963	0.3663	67.76
Run 10	0.4421	0.4121	65.67
Run 11	0.4879	0.4579	63.85
Run 12	0.5337	0.5037	62.25
Run 13	0.5795	0.5495	60.83
Run 14	0.6253	0.5953	59.56
Run 15	0.6711	0.6411	58.41
Run 16	0.7168	0.6868	57.37
Run 17	0.7626	0.7326	56.42
Run 18	0.8084	0.7784	55.55
Run 19	0.8542	0.8242	54.74
Run 20	0.9	0.87	54

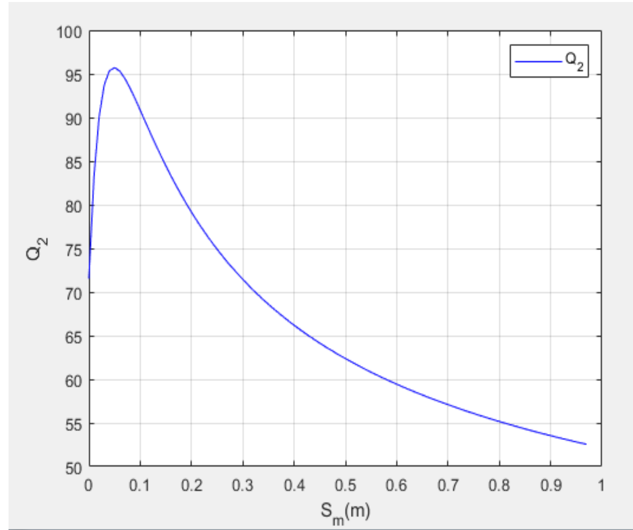


Critical Radius of insulation (rc):



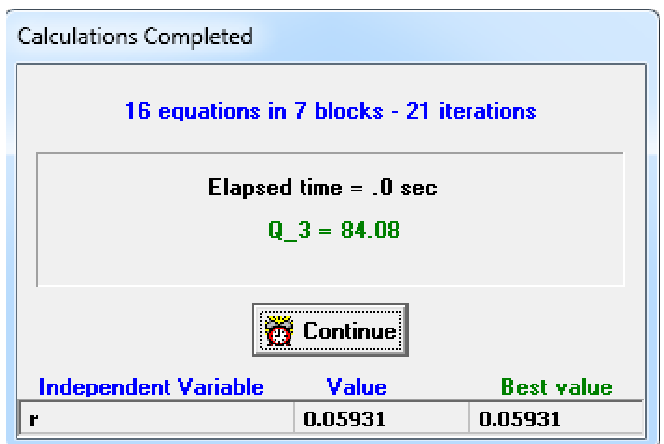
Matlab

```
clc,clear
rp=.03;k2=.4;Tamb=25;T=100;h=5;L=1;
r=.03:.01:1;
A=3.18*L*r*2;
R_CONV=1./(5*A);
R_INS=log(r/rp)/(2*3.14*k2*L);
R_TOT=R_INS+R_CONV;
Q_2=(T-Tamb)./R_TOT;
S_m=(r-rp);
plot(S_m,Q_2,'B')
legend('Q_2')
grid on
xlabel('S_m(m)')
ylabel('Q_2')
```

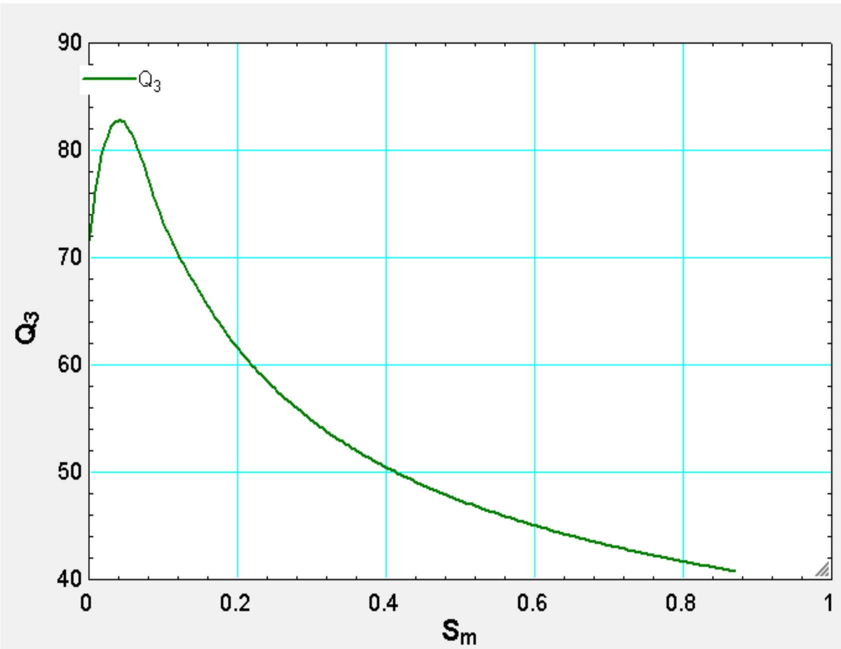


Critical Radius of insulation (rc):

```
"For Material c "
 r_p=.03[m]
L=1[m]
A=3.18*L*r*2
h=5[w/m^2.c]
T_surr=25[c]
T_1=100[c]
K_1=.5[w/m.c]
K_2=.4[w/m.c]
K_3=.3[w/m.c]
K_4=.2[w/m.c]
K_5=.05[w/m.c]
R_CONV=1/(h*A)
R_INS=ln(r/r_p)/(2*3.14*k_3*L)
R_TOT=R_INS+R_CONV
Q_3=(T_1-T_surr)/R_TOT
S_m=r-r_p
```



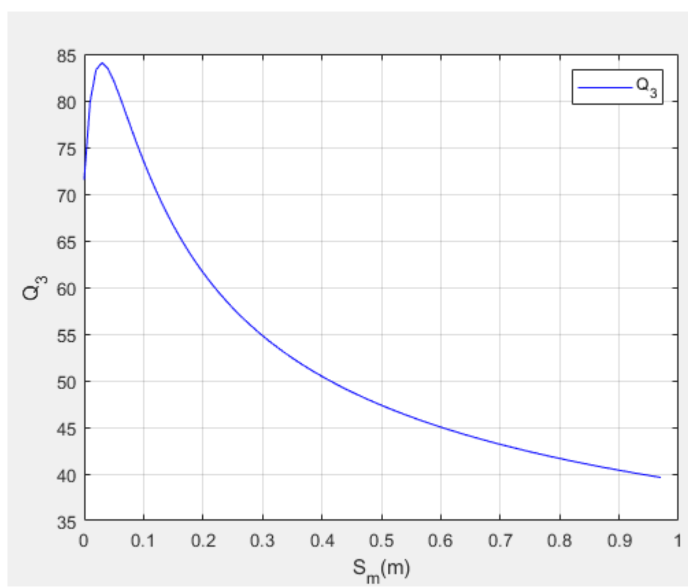
Graph



1..20	Q_4	r	S_m
Run 1	71.55	0.03	0
Run 2	65.06	0.07579	0.04579
Run 3	54.63	0.1216	0.09158
Run 4	48.18	0.1674	0.1374
Run 5	43.89	0.2132	0.1832
Run 6	40.82	0.2589	0.2289
Run 7	38.48	0.3047	0.2747
Run 8	36.64	0.3505	0.3205
Run 9	35.14	0.3963	0.3663
Run 10	33.89	0.4421	0.4121
Run 11	32.82	0.4879	0.4579
Run 12	31.9	0.5337	0.5037
Run 13	31.1	0.5795	0.5495
Run 14	30.39	0.6253	0.5953
Run 15	29.75	0.6711	0.6411
Run 16	29.18	0.7168	0.6868
Run 17	28.66	0.7626	0.7326
Run 18	28.18	0.8084	0.7784
Run 19	27.74	0.8542	0.8242
Run 20	27.34	0.9	0.87

Matlab

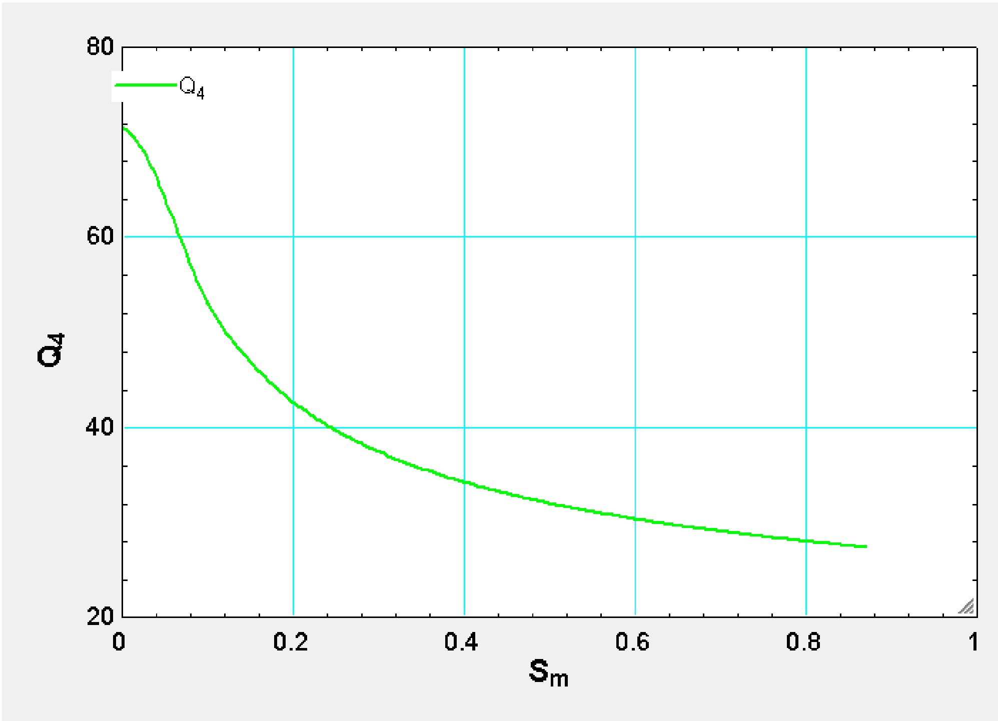
```
clc,clear
rp=.03;k3=.3;Tamb=25;T=100;h=5;L=1;
r=.03:.01:1;
A=3.18*L*r*2;
R_CONV=1./(5*A);
R_INS=log(r/rp)/(2*3.14*k3*L);
R_TOT=R_INS+R_CONV;
Q_3=(T-Tamb)./R_TOT;
S_m=(r-rp);
plot(S_m,Q_3,'B')
legend('Q_3')
grid on
xlabel('S_m(m)')
ylabel('Q_3')
```



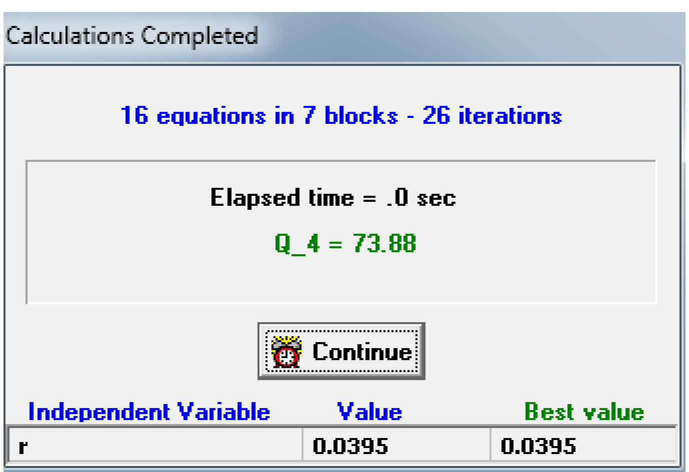
D:

```
"For Material D "
 r_p=.03[m]
L=1[m]
A=3.18*L*r*2
h=5[w/m^2.c]
T_surr=25[c]
T_1=100[c]
K_1=.5[w/m.c]
K_2=.4[w/m.c]
K_3=.3[w/m.c]
K_4=.2[w/m.c]
K_5=.05[w/m.c]
R_CONV=1/(h*A)
R_INS=ln(r/r_p)/(2*3.14*k_4*L)
R_TOT=R_INS+R_CONV
Q_4=(T_1-T_surr)/R_TOT
S_m=r-r_p
```

1..20	Q_4	r	S_m
Run 1	71.55	0.03	0
Run 2	65.06	0.07579	0.04579
Run 3	54.63	0.1216	0.09158
Run 4	48.18	0.1674	0.1374
Run 5	43.89	0.2132	0.1832
Run 6	40.82	0.2589	0.2289
Run 7	38.48	0.3047	0.2747
Run 8	36.64	0.3505	0.3205
Run 9	35.14	0.3963	0.3663
Run 10	33.89	0.4421	0.4121
Run 11	32.82	0.4879	0.4579
Run 12	31.9	0.5337	0.5037
Run 13	31.1	0.5795	0.5495
Run 14	30.39	0.6253	0.5953
Run 15	29.75	0.6711	0.6411
Run 16	29.18	0.7168	0.6868
Run 17	28.66	0.7626	0.7326
Run 18	28.18	0.8084	0.7784
Run 19	27.74	0.8542	0.8242
Run 20	27.34	0.9	0.87

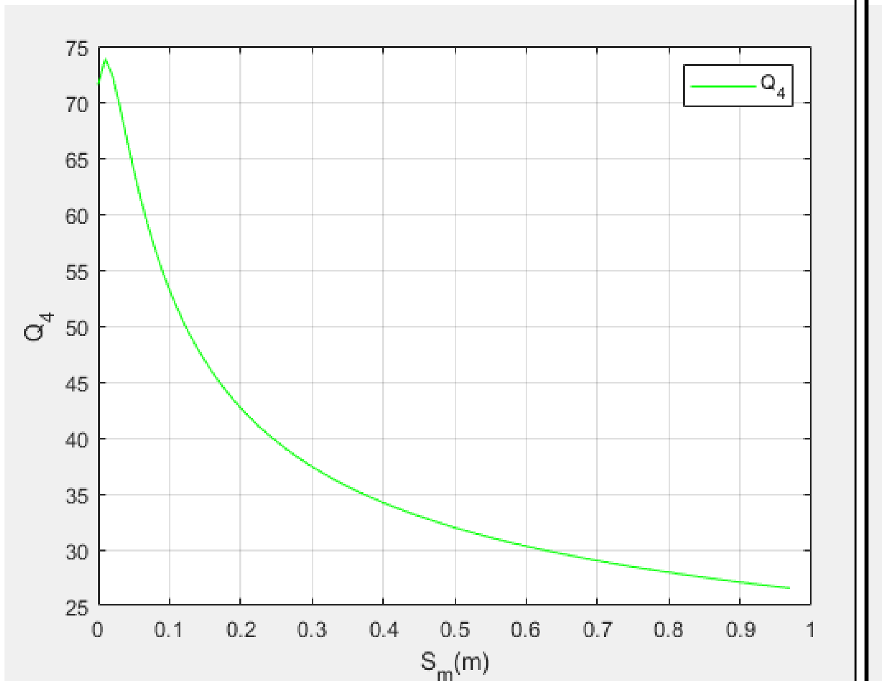


Critical Radius of insulation (rc):



Matlab

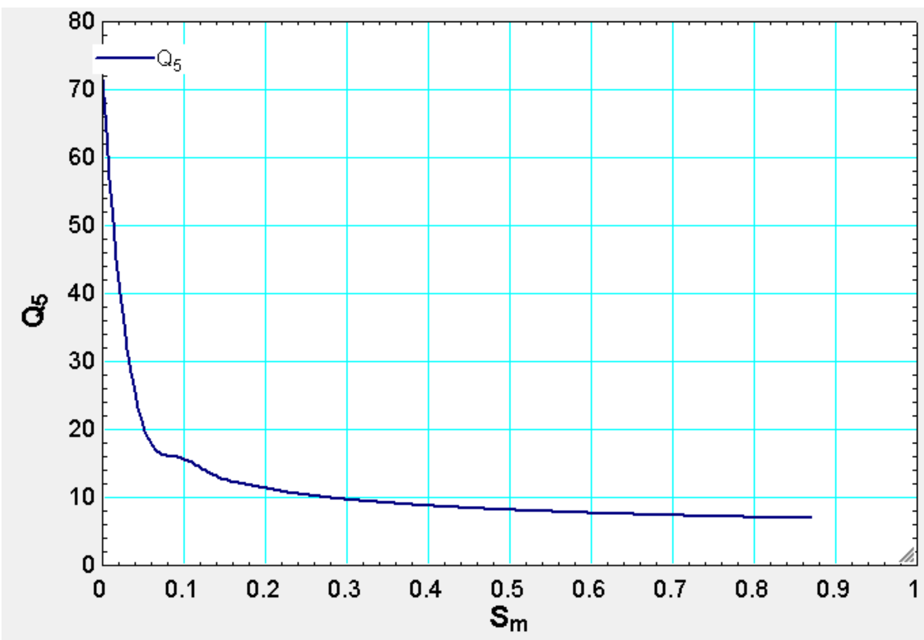
```
clc,clear
rp=.03;k4=.2;Tamb=25;T=100;h=5;L=1;
r=.03:.01:1;
A=3.18*L*r*2;
R_CONV=1./(5*A);
R_INS=log(r/rp)/(2*3.14*k4*L);
R_TOT=R_INS+R_CONV;
Q_4=(T-Tamb)./R_TOT;
S_m=(r-rp);
plot(S_m,Q_4,'G')
legend('Q_4')
grid on
xlabel('S_m(m)')
ylabel('Q_4')
```



E:

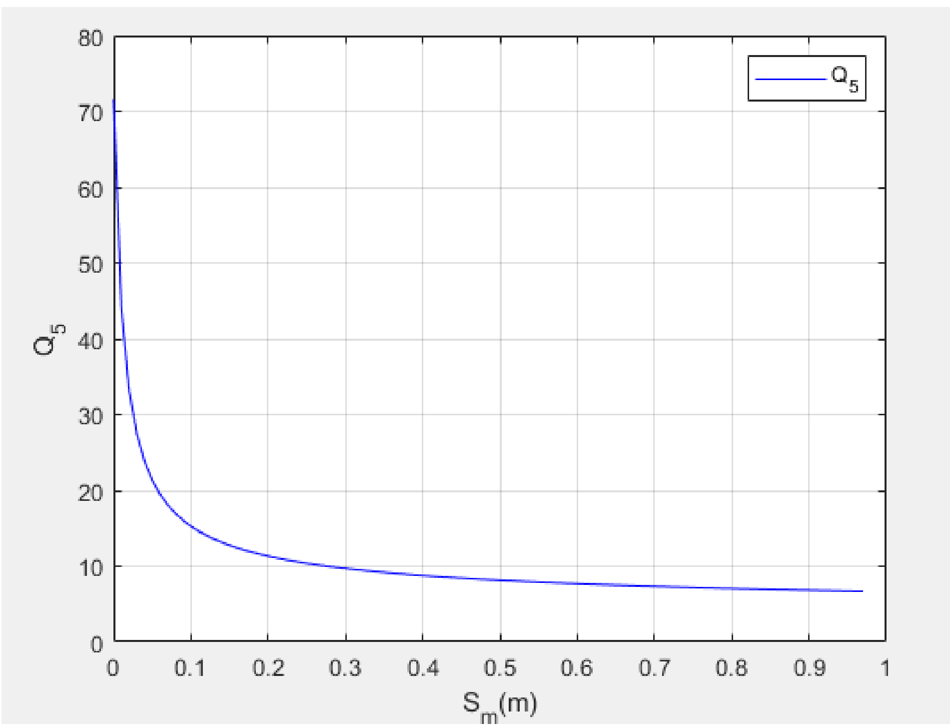
```
"For Material E "
 r_p=.03[m]
L=1[m]
A=3.18*L*r*2
h=5[w/m^2.c]
T_surr=25[c]
T_1=100[c]
K_1=.5[w/m.c]
K_2=.4[w/m.c]
K_3=.3[w/m.c]
K_4=.2[w/m.c]
K_5=.05[w/m.c]
R_CONV=1/(h*A)
R_INS=ln(r/r_p)/(2*3.14*k_5*L)
R_TOT=R_INS+R_CONV
Q_5=(T_1-T_surr)/R_TOT
S_m=r-r_p
```

1..20	r	Q_5	S_m
Run 1	0.03	71.55	0
Run 2	0.07579	22.28	0.04579
Run 3	0.1216	15.91	0.09158
Run 4	0.1674	13.25	0.1374
Run 5	0.2132	11.73	0.1832
Run 6	0.2589	10.74	0.2289
Run 7	0.3047	10.02	0.2747
Run 8	0.3505	9.471	0.3205
Run 9	0.3963	9.037	0.3663
Run 10	0.4421	8.681	0.4121
Run 11	0.4879	8.383	0.4579
Run 12	0.5337	8.129	0.5037
Run 13	0.5795	7.908	0.5495
Run 14	0.6253	7.714	0.5953
Run 15	0.6711	7.542	0.6411
Run 16	0.7168	7.388	0.6868
Run 17	0.7626	7.249	0.7326
Run 18	0.8084	7.123	0.7784
Run 19	0.8542	7.008	0.8242
Run 20	0.9	6.902	0.87



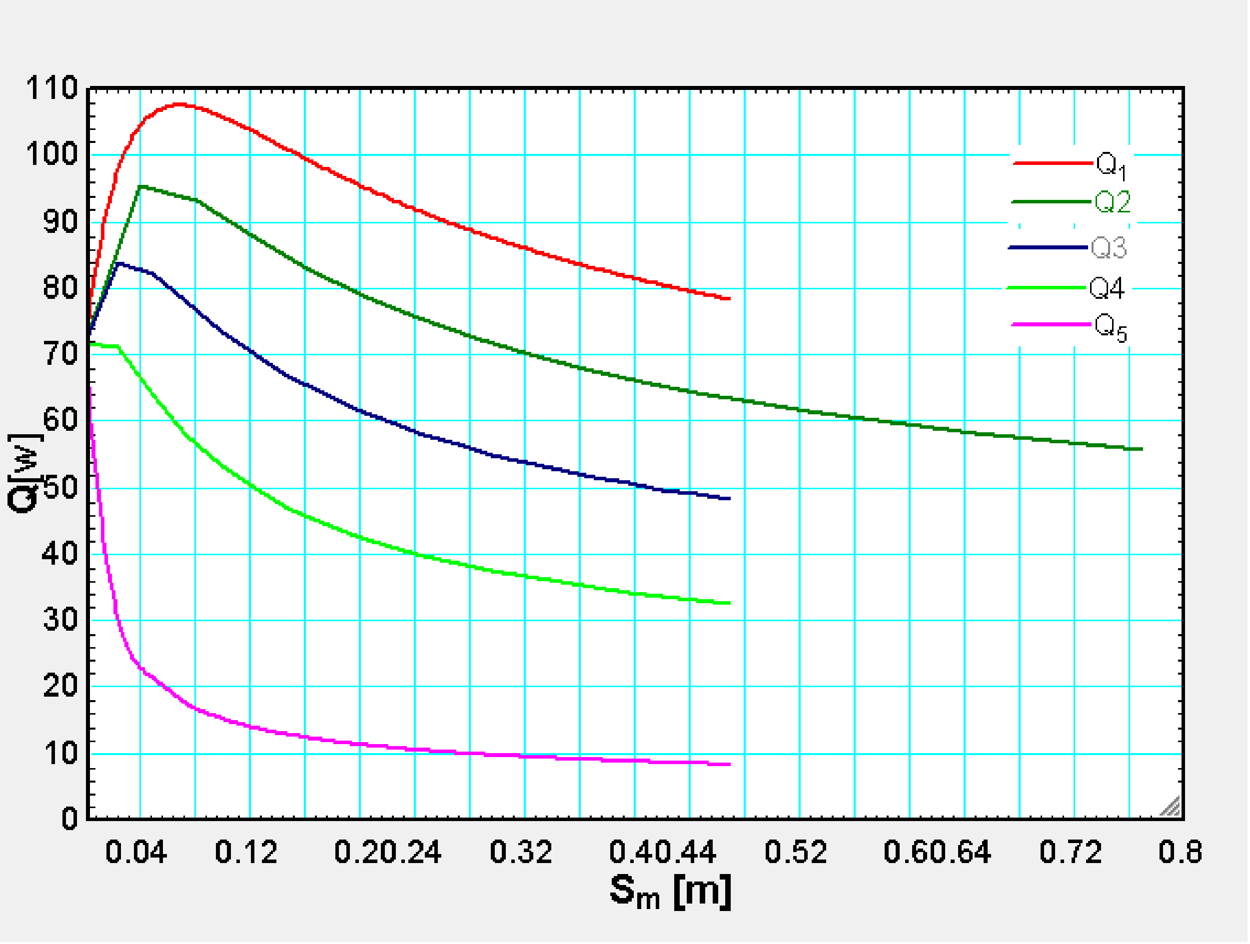
Matlab

```
clc,clear
rp=.03;k5=.05;Tamb=25;T=100;h=5;L=1;
r=.03:.01:1;
A=3.18*L*r*2;
R_CONV=1./(5*A);
R_INS=log(r/rp)/(2*3.14*k5*L);
R_TOT=R_INS+R_CONV;
Q_5=(T-Tamb)./R_TOT;
S_m=(r-rp);
plot(S_m,Q_5,'B')
legend('Q_5')
grid on
xlabel('S_m(m)')
ylabel('Q_5')
```



Rc<rpipe

All Graphs:



Decreasing K Lead to decreasing Critical Radius of insulation and increasing cost .

2:

From graph :

Q loss without insulation =70.68 W

TO Reduce Q loss ..use insulation

Q..loss new = 70.68*.5= 35.34W

From EES

Thickness of Material A=23.49m

q_1	$s_{thickness}$	r	T
36.36	19.42	19.45	25.06
36.29	19.67	19.7	25.06
36.22	19.93	19.96	25.06
36.15	20.18	20.21	25.06
36.08	20.43	20.46	25.06
36.02	20.68	20.71	25.06
35.95	20.93	20.96	25.05
35.88	21.19	21.22	25.05
35.82	21.44	21.47	25.05
35.76	21.69	21.72	25.05
35.69	21.94	21.97	25.05
35.63	22.2	22.23	25.05
35.57	22.45	22.48	25.05
35.51	22.7	22.73	25.05
35.45	22.95	22.98	25.05
35.4	23.2	23.23	25.05
35.34	23.46	23.49	25.05

Thickness of Material B=6.1m

$cost_2$	q_2	r	$s_{thickness}$	T
272110	36.23	5.373	5.343	25.21
279184	36.14	5.443	5.413	25.21
286349	36.05	5.512	5.482	25.21
293605	35.97	5.582	5.552	25.21
300951	35.89	5.651	5.621	25.2
308388	35.8	5.72	5.69	25.2
315916	35.72	5.79	5.76	25.2
323534	35.64	5.859	5.829	25.19
331244	35.57	5.928	5.898	25.19
339044	35.49	5.998	5.968	25.19
346935	35.41	6.067	6.037	25.19
354916	35.34	6.137	6.107	25.18

Thickness of Material C=1.55m

q_3	$cost_3$	r	$s_{thickness}$	T
36.81	27992	1.335	1.305	25.88
36.47	30137	1.385	1.355	25.84
36.16	32362	1.436	1.406	25.8
35.85	34666	1.486	1.456	25.77
35.57	37049	1.536	1.506	25.74
35.29	39511	1.586	1.556	25.71

Thickness of Material D=0.359 m

$cost_4$	q_4	r	$s_{thickness}$	T
2382	38.27	0.3093	0.2793	28.94
3042	36.69	0.3492	0.3192	28.34
3782	35.36	0.3891	0.3591	27.89

Thickness of Material E=.017 m

$cost_5$	q_5	r	$s_{thickness}$	T
0	70.69	0.03	0	100
61.1	35.73	0.04687	0.01687	49.26

3-

Material	K_{ins}	R_c = K_{ins}/h	R_{ins}	Thickness = R_{ins} – R_{pipe}	Volume = $\pi((R_{ins})^2 - (R_{pipe})^2)$	Cost (LE) = volume * cost(LE/m^3)	T(℃)
A	0.5	0.1	23.47	23.44	1726.093	1726093	25.05
B	0.4	0.08	6.133	6.103	118.16	354492.2	25.184
C	0.3	0.06	1.577	1.547	7.81	39050.452	25.71
D	0.2	0.04	0.3896	0.3596	0.4740	3792.233	27.89
E	0.05	0.01	0.0473	0.0173	$4.2012*10^{-3}$	63.018	49

Cost=cost(L.M/m^3)*(pi/4*(r_outer^2_r_pipe^2)*L)

Temperture of Insulation

Qloss=(100_T)/ln(r/r pipe)/(2*pi*k*L)

Qloss=35.34W

R_{pipe} = 0.03m

h = 5 W/m^2. ℃

we will choose material (E) to use because it has:

1. Least critical radius of insulation (Rc)
2. Least thickness
3. Least cost