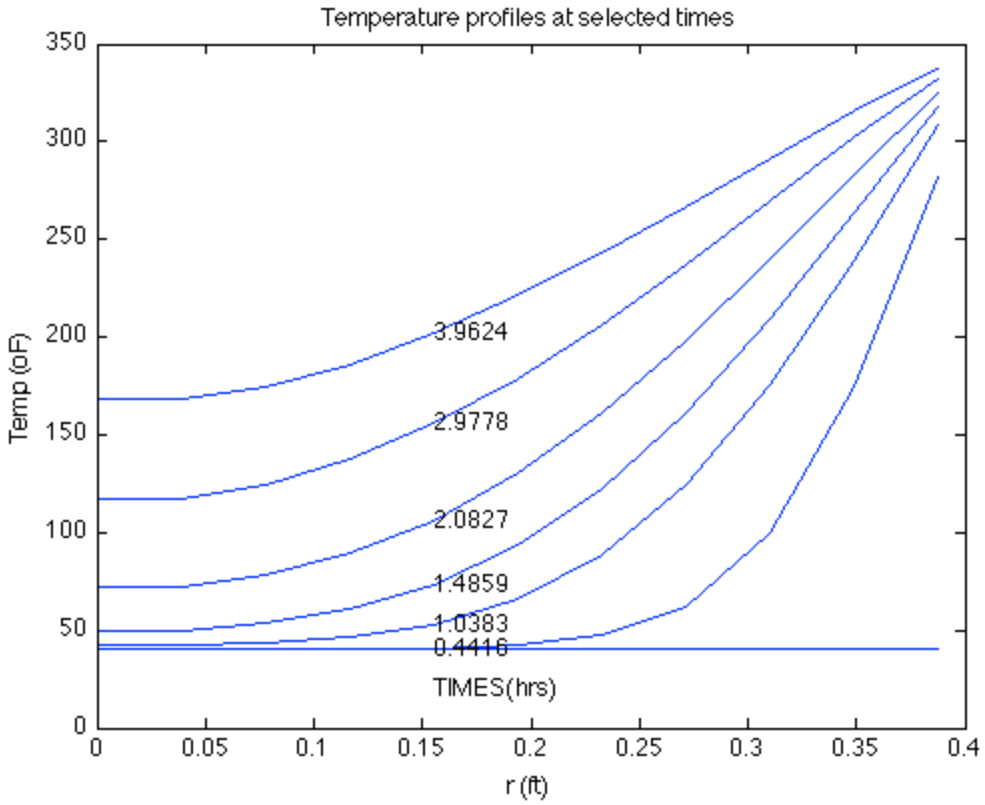
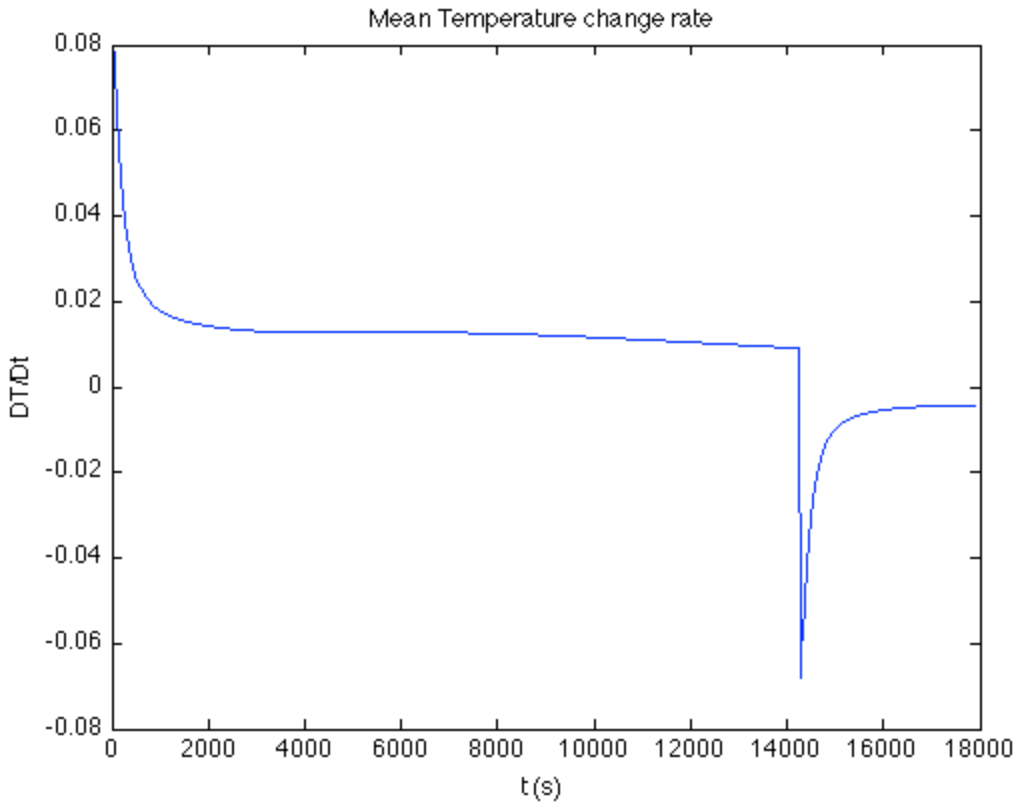
```
% MAE315 Computer Project
% Unsteady conduction heat transfer
% Crank-Nicolson method
%
format short g
% fixed parameters
%
% boundary conditions
TIN=40;h=12.5;tk=0.287;alfa=1.40e-6;TINF=350;
m=16;rho=65.5;r0=(m/(4/3*pi*rho))^(1/3);
%
% grid-nodes
N=10;NP1=N+1;
dr=r0/N;
r=0:dr:r0;r(1)=eps;
rm=-dr/2:dr:r0;rm(1)=0;
rp=dr/2:dr:r0;rp(NP1)=r0;
% intilization
maxts=835;
t(1:NP1)=0;DT(1:NP1,1)=0;
T(1:NP1,1)=TIN;
%time-marching process
%choose lam value than calculate dt
lam=0.02;
dt=lam*dr^2/alfa;
for k=2:maxts
    % Rest Time
    if k>665
        TINF=70;
    end
    t(k)=t(k-1)+dt;
    %
    for i=2:NP1
        a(i)=-lam/2*rm(i)^2/r(i)^2;
        b(i)=(1+1*lam/2*(rm(i)^2+rp(i)^2)/r(i)^2);
        c(i)=-lam/2*rp(i)^2/r(i)^2;
    end
    for i=2:N
        d(i)=(lam/2*rm(i)^2/r(i)^2*T(i-1,k-1)+(1-lam/2*(rm(i)^2+rp(i)^2)/r(i)^2)...
            *T(i,k-1)+lam/2*rp(i)^2/r(i)^2*T(i+1,k-1));
    end
    %apply boundary conditions
    a(1)=0;
    b(1)=(1+1*lam/2*(rm(1)^2+rp(1)^2)/(r(1)^2+eps));
    c(1)=-lam/2*(rm(1)^2+rp(1)^2)/(r(1)^2+eps);
    d(1)=(1-lam/2*(rm(1)^2+rp(1)^2)/(r(1)^2+eps))*T(1,k-1)+lam/2*(rm(1)^2+rp(1)^2)..
        /(r(1)^2+eps)*T(2,k-1);
    a(NP1)=-lam/2*(rm(NP1)^2+rp(NP1)^2)/(r(NP1)^2+eps);
    b(NP1)=(1+lam/2*(rm(NP1)^2+rp(NP1)^2)/(r(NP1)^2+eps)+lam*h*dr/tk);
    c(NP1)=0;
    d(NP1)=lam/2*(rm(NP1)^2+rp(NP1)^2)/(r(NP1)^2+eps)*T(N,k-1)...
        +(1-lam/2*(rm(NP1)^2+rp(NP1)^2)/(r(NP1)^2+eps)...
        -lam*rp(NP1)^2/r(NP1)^2*h*dr/tk)*T(NP1,k-1)...
        +2*lam*rp(NP1)^2/r(NP1)^2*h*dr/tk*TINF;
```

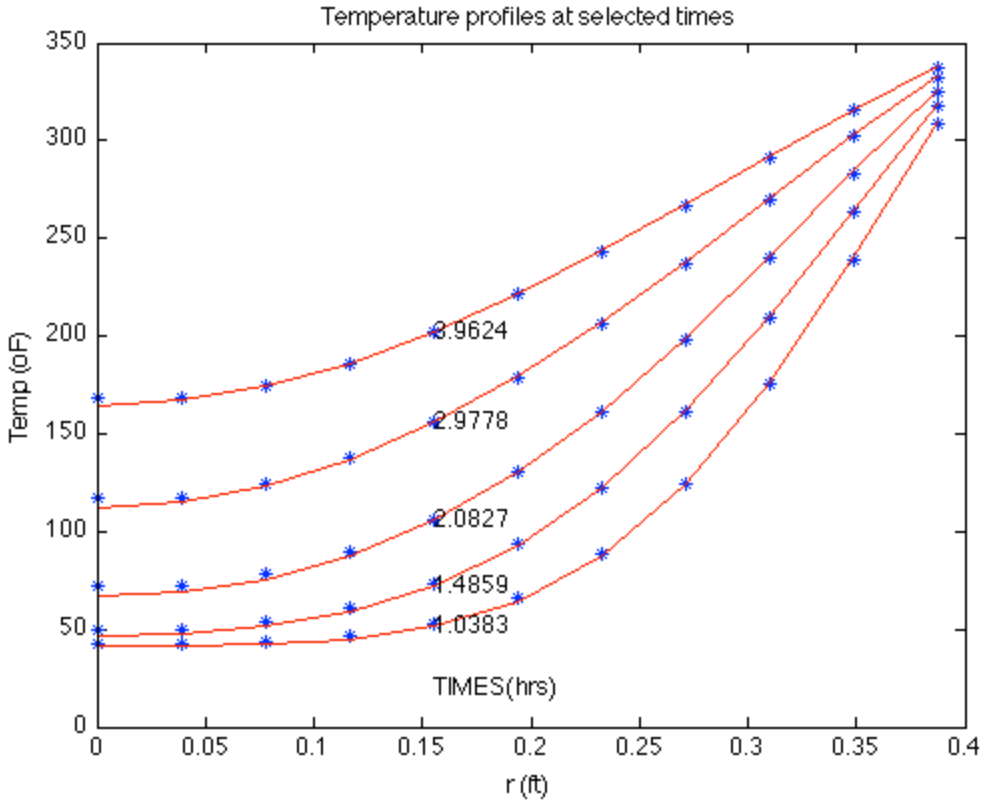
```
    %
    TT=trid(a,b,c,d);
    for i=1:NP1
        T(i,k)=TT(i);

        %calculate DT/Dt
        DT(i,k)=(T(i,k)-T(i,k-1))/dt;
    end
end
%
%plot the results
%first choose time steps to plot profiles
%
nt=7;tpl=[1 75 175 250 350 500 665];
tpl(1)=1;
Times=t(tpl)/3600
figure
for kk=1:nt
    tpp(kk)=t(tpl(kk));
    TP(:,kk)=T(:,tpl(kk));
    plot(r,T(:,tpl(kk)))
    text(r(5),TP(5,kk),num2str(Times(kk)))
    hold on
end
text(r(5),TINF-50,'TIMES(hrs)')
xlabel('r (ft)');ylabel('Temp (oF)');title('Temperature profiles at selected times')
hold off
% plot mean DT/Dt excl first 2 times
figure
tp=t(3:maxts);DTm=mean(DT);DTp=DTm(3:maxts);
plot(tp,DTp)
xlabel('t (s)');ylabel('DT/Dt');title('Mean Temperature change rate')
%
%compare analytical and numerical results
%
rk=(r/r0);
figure
for kk=3:7
    T_S=pturkey_fn(r0,rk,tpp(kk));
    plot(r,TP(:,kk),'*',r,T_S,'r-')
    text(r(5),T_S(5),num2str(Times(kk)))
    hold on
end
xlabel('r (ft)');ylabel('Temp (oF)');title('Temperature profiles at selected times')
text(r(5),TINF-50,'TIMES(hrs)')
%
TR0=T(:,665);TR1=T(:,750);TR2=T(:,835);
fprintf(' After rest time of %7.2f minutes, Temperature profiles (r,T_0,T_30,T_60) a
    ,[(t(835)-t(665))/60])
fprintf('  %5.3f %7.2f %7.2f %7.2f\n',[r;TR0';TR1';TR2'])
%
%plot rest period temperatures
%
TR0=T(:,665);TR1=T(:,750);TR2=T(:,835);
figure
plot(r,TR0,'bo--',r,TR1,'mo--',r,TR2,'ro--')
```

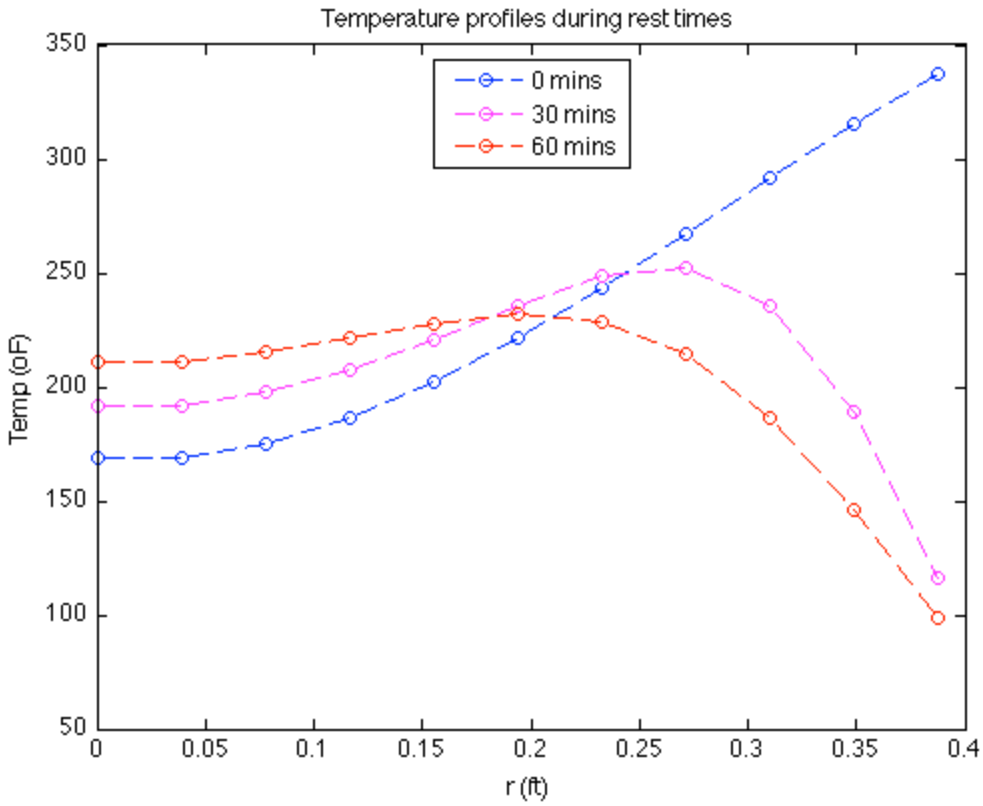
```
xlabel('r (ft)');ylabel('Temp (oF)');title('Temperature profiles during rest times')
legend('0 mins','30 mins','60 mins','Location','Best')
```

```
Times =

         0       0.4416       1.0383       1.4859       2.0827       2.9778

 After rest time of   60.87 minutes, Temperature profiles (r,T_0,T_30,T_60) are
   0.000  168.48  191.76  210.98
  0.039  168.48  191.76  210.98
  0.078  174.88  197.48  215.02
  0.116  186.18  207.45  221.34
  0.155  201.80  220.74  227.96
  0.194  221.05  235.66  231.83
  0.233  243.12  248.58  228.87
  0.271  266.97  252.35  214.74
  0.310  291.43  235.87  186.72
  0.349  315.26  189.21  145.96
  0.388  337.26  116.13   98.59
```




Mean Temperature change rate
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
DT/Dt
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
t (s)


Temperature profiles at selected times
350
300
250
200
150
100
50
0
Temp (oF)
3.9624
2.9778
2.0827
1.4859
1.0383
TIMES(hrs)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
r (ft)

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