



LAMPIRAN 1

Listing Program untuk Gambar 4.1

```
(em, mil, rk, eksplisit 4 grafik)
% SDE is  $dX = (\mu-D)*X dt + vol*X dW$ ,  $X(0) = Xzero$ ,
% where  $\mu = 0.050481986$ ;  $D = 0.019869514$ ;  $vol = 0.23352995$ ;  $Xzero = 33.72$ ;
% Discretized Brownian path over  $[0,1]$  has  $dt = 2^{(-10)}$ .
% Numerical methods uses timestep  $R*dt = 2^{(-8)}$ .

clear;clc;
randn('state',sum(clock*100))
rand('state',sum(clock*1000))
mu = 0.050481986; D = 0.019869514; vol = 0.23352995; Xzero = 33.72; %
problem parameters
T = 2; N = 2*4*250; dt = T/N; M=1000;
R = 4; Dt = R*dt; L = N/R; % L steps of size  $Dt = R*dt$ 

for i = 1:M
    Xtrue = Xzero;
    Xtemp = Xzero;
    XtempM = Xzero;
    XtempR = Xzero;
    dW1 = sqrt(dt)*randn(1,N); % Brownian increments
    dW2 = sqrt(dt)*rand(1,N); % Brownian increments
    W1=cumsum(dW1,2);
    W2=cumsum(dW2,2);
    for j = 1:L
        Wincl = sum(dW1(R*(j-1)+1:R*j));
        Winc2 = sum(dW2(R*(j-1)+1:R*j));
        Xtrue = Xtrue * exp((mu-D-(vol^2)/2)*Dt + vol*Wincl);
        Xtemp = Xtemp + Dt*(mu-D)*Xtemp + vol*Xtemp*Wincl;
        XtempM = XtempM + Dt*(mu-D)*XtempM + vol*XtempM*Wincl +
            0.5*vol^2*XtempM*((Wincl^2)-Dt);

        k1=(mu-D)*XtempR ;
        kk1=vol*XtempR ;
        K1=vol*XtempR ;
        KK1=vol*XtempR ;

        k2=(mu-D)*(XtempR+Dt*((1/2)*k1)+Wincl*((1/2)*kk1)+
            (Winc2/sqrt(3))*((1/2)*K1)) ;
        kk2=vol*(XtempR+Dt*((1/2)*k1)+Wincl*((1/2)*kk1)+
            (sqrt(3*Dt))*((-1)*KK1)) ;
        K2=vol*(XtempR+Dt*((1/2)*k1)+(sqrt(3*Dt))*((-1)*KK1)) ;
        KK2=vol*(XtempR+(sqrt(3*Dt))*((-1)*KK1)) ;

        k3=(mu-D)*(XtempR+Dt*((1/4)*k1+(1/4)*k2)+
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Winc1*((1/4)*kk1+(1/4)*kk2)+(Winc2/sqrt(3))*((1/2)*K2) ;
kk3=vol*(XtempR+Dt*((1/4)*k1+(1/4)*k2)+
Winc1*((1/4)*kk1+(1/4)*kk2)+(sqrt(3*Dt))*((-13/32)*KK1+
(5/32)*KK2) ;
K3=vol*(XtempR+Dt*((1/4)*k1+(1/4)*k2)+(sqrt(3*Dt))*
((-13/32)*KK1+(5/32)*KK2) ;
KK3=vol*(XtempR+(sqrt(3*Dt))*((-13/32)*KK1+(5/32)*KK2) ;

k4=(mu-D)*(XtempR+Dt*((1/3)*k1+
(-2)*k2+(8/3)*k3)+Winc1*((1/3)*kk1+
(-2)*kk2+(8/3)*kk3)+(Winc2/sqrt(3))*((1)*K3) ;
kk4=vol*(XtempR+Dt*((1/3)*k1+
(-2)*k2+(8/3)*k3)+Winc1*((1/3)*kk1+
(-2)*kk2+(8/3)*kk3)+(sqrt(3*Dt))*
((-7/24)*KK1+(1/8)*KK2+(1/6)*KK3) ;
K4=vol*(XtempR+Dt*((1/3)*k1+
(-2)*k2+(8/3)*k3)+(sqrt(3*Dt))*
((-7/24)*KK1+(1/8)*KK2+(1/6)*KK3) ;
KK4=vol*(XtempR+(sqrt(3*Dt))*
((-7/24)*KK1+(1/8)*KK2+(1/6)*KK3) ;

XtempR=XtempR+(1/6)*k1-(2/9)*k2+(8/9)*k3+
(1/6)*k4)*Dt+((1/6)*kk1-(2/9)*kk2+(8/9)*kk3+
(1/6)*kk4)*Winc1+(1/sqrt(3))*((1/6)*K1-(2/9)*K2+
(8/9)*K3-(5/6)*K4)*Winc2+((-1/18)*KK2+(8/9)*KK3+
(-5/6)*KK4)*sqrt(3*Dt);

Xem(j) = Xtemp;
XemM(j) = XtempM;
XemR(j) = XtempR;
Xtruee(j) = Xtrue;
end
if i==1
    V=Xem;
    U=XemM;
    Z=XemR;
    Y=Xtruee;
else
    V=[V;Xem];
    U=[U;XemM];
    Z=[Z;XemR];
    Y=[Y;Xtruee];
end
end
Vmean=mean(V);
Umean=mean(U);
Zmean=mean(Z);
Ymean=mean(Y);

subplot(1, 4, 1),plot([0:Dt:T],[Xzero,Vmean],'r-
',[0:Dt:T],[[Xzero;Xzero;Xzero;Xzero;Xzero],V(1:5,:)],'-b'),hold on
h=legend('mean of 1000 paths','5 individual paths',2);
set(h,'Interpreter','none');
xlabel('t','FontSize',12)

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ylabel('S(t)', 'FontSize',16, 'Rotation',0, 'HorizontalAlignment', 'right')
title('EM Method', 'FontSize',10)

subplot(1, 4, 2), plot([0:Dt:T], [Xzero, Umean], 'r-',
', [0:Dt:T], [[Xzero;Xzero;Xzero;Xzero;Xzero], U(1:5, :)], '-g'), hold on
b=legend('mean of 1000 paths', '5 individual paths', 2);
set(b, 'Interpreter', 'none');
xlabel('t', 'FontSize',12)
ylabel('S(t)', 'FontSize',16, 'Rotation',0, 'HorizontalAlignment', 'right')
title('Milstein Method', 'FontSize',10)

subplot(1, 4, 3), plot([0:Dt:T], [Xzero, Zmean], 'r-',
', [0:Dt:T], [[Xzero;Xzero;Xzero;Xzero;Xzero], Z(1:5, :)], '-k'), hold on
q=legend('mean of 1000 paths', '5 individual paths', 2);
set(q, 'Interpreter', 'none');
xlabel('t', 'FontSize',12)
ylabel('S(t)', 'FontSize',16, 'Rotation',0, 'HorizontalAlignment', 'right')
title('Prediksi Harga Saham 2009 dengan RK Method', 'FontSize',10)

subplot(1, 4, 4), plot([0:Dt:T], [Xzero, Ymean], 'r-',
', [0:Dt:T], [[Xzero;Xzero;Xzero;Xzero;Xzero], Y(1:5, :)], '-m'), hold off
c=legend('mean of 1000 paths', '5 individual paths', 2);
set(c, 'Interpreter', 'none');
xlabel('t', 'FontSize',12)
ylabel('S(t)', 'FontSize',16, 'Rotation',0, 'HorizontalAlignment', 'right')
title('Explicit Method', 'FontSize',10)

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Listing Program untuk Gambar 4.2

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%(em, mil, rk, eksplisit 1 grafik)
% SDE is  $dX = (\mu - D) * X dt + vol * X dW$ ,  $X(0) = Xzero$ ,
% where  $\mu = 0.284349207$ ;  $D = 0.02546257$ ;  $vol = 0.187010224$ ;  $Xzero = 58.91$ ;
% Discretized Brownian path over [0,1] has  $dt = 2^{(-10)}$ .
% Numerical methods uses timestep  $R * dt = 2^{(-8)}$ .
clear;clc;
randn('state', sum(clock*100))
rand('state', sum(clock*1000))
mu = 0.284349207; D = 0.02546257; vol = 0.187010224; Xzero = 58.91; %
problem parameters
T = 1; N = 4*250; dt = T/N; M=1000;
R = 4; Dt = R*dt; L = N/R; % L steps of size Dt = R*dt

for i = 1:M

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Xtrue = Xzero;
Xtemp = Xzero;
XtempM = Xzero;
XtempR = Xzero;
dW1 = sqrt(dt)*randn(1,N); % Brownian increments
dW2 = sqrt(dt)*rand(1,N); % Brownian increments
W1=cumsum(dW1,2);
W2=cumsum(dW2,2);
for j = 1:L
    Winc1 = sum(dW1(R*(j-1)+1:R*j));
    Winc2 = sum(dW2(R*(j-1)+1:R*j));
    Xtrue = Xtrue * exp((mu-D-(vol^2)/2)*Dt + vol*Winc1);
    Xtemp = Xtemp + Dt*(mu-D)*Xtemp + vol*Xtemp*Winc1;
    XtempM = XtempM + Dt*(mu-D)*XtempM + vol*XtempM*Winc1 +
    0.5*vol^2*XtempM*((Winc1^2)-Dt);

    k1=(mu-D)*XtempR ;
    kk1=vol*XtempR ;
    K1=vol*XtempR ;
    KK1=vol*XtempR ;

    k2=(mu-D)*(XtempR+Dt*((1/2)*k1)+Winc1*((1/2)*kk1)+
    (Winc2/sqrt(3))*((1/2)*K1)) ;
    kk2=vol*(XtempR+Dt*((1/2)*k1)+Winc1*((1/2)*kk1)+
    (sqrt(3*Dt))*((-1)*KK1)) ;
    K2=vol*(XtempR+Dt*((1/2)*k1)+(sqrt(3*Dt))*((-1)*KK1)) ;
    KK2=vol*(XtempR+(sqrt(3*Dt))*((-1)*KK1)) ;

    k3=(mu-D)*(XtempR+Dt*((1/4)*k1+(1/4)*k2)+
    Winc1*((1/4)*kk1+(1/4)*kk2)+(Winc2/sqrt(3))*((1/2)*K2)) ;
    kk3=vol*(XtempR+Dt*((1/4)*k1+(1/4)*k2)+
    Winc1*((1/4)*kk1+(1/4)*kk2)+(sqrt(3*Dt))*
    ((-13/32)*KK1+(5/32)*KK2)) ;
    K3=vol*(XtempR+Dt*((1/4)*k1+(1/4)*k2)+
    (sqrt(3*Dt))*((-13/32)*KK1+(5/32)*KK2)) ;
    KK3=vol*(XtempR+(sqrt(3*Dt))*((-13/32)*KK1+(5/32)*KK2)) ;

    k4=(mu-D)*(XtempR+Dt*((1/3)*k1+
    (-2)*k2+(8/3)*k3)+Winc1*((1/3)*kk1+
    (-2)*kk2+(8/3)*kk3)+(Winc2/sqrt(3))*((1)*K3)) ;
    kk4=vol*(XtempR+Dt*((1/3)*k1+
    (-2)*k2+(8/3)*k3)+Winc1*((1/3)*kk1+
    (-2)*kk2+(8/3)*kk3)+(sqrt(3*Dt))*((-7/24)*KK1+
    (1/8)*KK2+(1/6)*KK3)) ;
    K4=vol*(XtempR+Dt*((1/3)*k1+(-2)*k2+
    (8/3)*k3)+(sqrt(3*Dt))*((-7/24)*KK1+(1/8)*KK2+(1/6)*KK3)) ;
    KK4=vol*(XtempR+(sqrt(3*Dt))*((-7/24)*KK1+
    (1/8)*KK2+(1/6)*KK3)) ;

    XtempR=XtempR+((1/6)*k1-(2/9)*k2+
    (8/9)*k3+(1/6)*k4)*Dt+((1/6)*kk1-(2/9)*kk2+
    (8/9)*kk3+(1/6)*kk4)*Winc1+(1/sqrt(3))*((1/6)*K1-(2/9)*K2+
    (8/9)*K3-(5/6)*K4)*Winc2+((-1/18)*KK2+(8/9)*KK3+(-5/6)*KK4)

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*sqrt(3*Dt);

Xem(j) = Xtemp;
XemM(j) = XtempM;
XemR(j) = XtempR;
Xtruee(j) = Xtrue;
end
if i==1
    V=Xem;
    U=XemM;
    Z=XemR;
    Y=Xtruee;
else
    V=[V;Xem];
    U=[U;XemM];
    Z=[Z;XemR];
    Y=[Y;Xtruee];
end
end
Vmean=mean(V);
Umean=mean(U);
Zmean=mean(Z);
Ymean=mean(Y);

plot([0:Dt:T],[Xzero,V(100:100,:)],'-
b',[0:Dt:T],[Xzero,U(100:100,:)],'g-
',[0:Dt:T],[Xzero,Z(100:100,:)],'k-
',[0:Dt:T],[Xzero,Y(100:100,:)],'m-',[0:Dt:T],[Xzero,Ymean],'r-
'),hold off
h=legend('em','mil','rk','eksplisit','mean',5);
set(h,'Interpreter','none');
xlabel('t','FontSize',12)
ylabel('S(t)','FontSize',16,'Rotation',0,'HorizontalAlignment','right')
title('delta t = 1/(2^8) untuk setiap metode','FontSize',10)

emerr = sqrt((Xem(end)-Xtruee(end))^2)
emerrM = sqrt((XemM(end)-Xtruee(end))^2)
emerrR = sqrt((XemR(end)-Xtruee(end))^2)

```

Listing Program untuk Gambar 4.3

```

%(RMSE vs delta t)
% SDE is  $dX = (\mu - D)X dt + \text{vol} * X dW$ ,  $X(0) = Xzero$ ,
% where  $\mu = 0.284349207$ ;  $D = 0.02546257$ ;  $\text{vol} = 0.187010224$ ;  $Xzero = 58.91$ ;
% Discretized Brownian path over [0,1]
clear;clc;
randn('state',sum(clock*100))

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rand('state',sum(clock*1000))
mu = 0.284349207; D = 0.02546257; vol = 0.187010224; Xzero = 58.91;
% problem parameters
p=10;
for q = 1 :10
    p = 2*p;
    T = 1; N = 4*p; dt = T/N; M=1000;
    R = 4; Dt = R*dt; L = N/R; % L steps of size Dt = R*dt

    for i = 1:M
        Xtrue = Xzero;
        Xtemp = Xzero;
        XtempM = Xzero;
        XtempR = Xzero;
        dW1 = sqrt(dt)*randn(1,N); % Brownian increments
        dW2 = sqrt(dt)*rand(1,N); % Brownian increments
        W1=cumsum(dW1,2);
        W2=cumsum(dW2,2);
        for j = 1:L
            Winc1 = sum(dW1(R*(j-1)+1:R*j));
            Winc2 = sum(dW2(R*(j-1)+1:R*j));
            Xtrue = Xtrue * exp((mu-D-(vol^2)/2)*Dt + vol*Winc1);
            Xtemp = Xtemp + Dt*(mu-D)*Xtemp + vol*Xtemp*Winc1;
            XtempM = XtempM + Dt*(mu-D)*XtempM + vol*XtempM*Winc1 +
                0.5*vol^2*XtempM*(Winc1^2)-Dt);
            k1=(mu-D)*XtempR ;
            kk1=vol*XtempR ;
            K1=vol*XtempR ;
            KK1=vol*XtempR ;

            k2=(mu-D)*(XtempR+Dt*((1/2)*k1)+Winc1*((1/2)*kk1)+
                (Winc2/sqrt(3))*((1/2)*K1)) ;
            kk2=vol*(XtempR+Dt*((1/2)*k1)+Winc1*((1/2)*kk1)+
                (sqrt(3*Dt))*((-1)*KK1)) ;
            K2=vol*(XtempR+Dt*((1/2)*k1)+(sqrt(3*Dt))*((-1)*KK1)) ;
            KK2=vol*(XtempR+(sqrt(3*Dt))*((-1)*KK1)) ;

            k3=(mu-D)*(XtempR+Dt*((1/4)*k1+(1/4)*k2)+
                Winc1*((1/4)*kk1+(1/4)*kk2)+(Winc2/sqrt(3))*((1/2)*K2));
            kk3=vol*(XtempR+Dt*((1/4)*k1+(1/4)*k2)+
                Winc1*((1/4)*kk1+(1/4)*kk2)+(sqrt(3*Dt))*
                ((-13/32)*KK1+(5/32)*KK2)) ;
            K3=vol*(XtempR+Dt*((1/4)*k1+(1/4)*k2)+(sqrt(3*Dt))*
                ((-13/32)*KK1+(5/32)*KK2)) ;
            KK3=vol*(XtempR+(sqrt(3*Dt))*((-13/32)*KK1+(5/32)*KK2));

            k4=(mu-D)*(XtempR+Dt*((1/3)*k1+(-2)*k2+(8/3)*k3)+
                Winc1*((1/3)*kk1+(-2)*kk2+(8/3)*kk3)+
                (Winc2/sqrt(3))*((1)*K3)) ;
            kk4=vol*(XtempR+Dt*((1/3)*k1+(-2)*k2+(8/3)*k3)+
                Winc1*((1/3)*kk1+(-2)*kk2+(8/3)*kk3)+
                (sqrt(3*Dt))*((-7/24)*KK1+(1/8)*KK2+(1/6)*KK3)) ;

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```

K4=vol*(XtempR+Dt*((1/3)*k1+(-2)*k2+(8/3)*k3)+
(sqrt(3*Dt))*((-7/24)*KK1+(1/8)*KK2+(1/6)*KK3) ;
KK4=vol*(XtempR+(sqrt(3*Dt))*((-7/24)*KK1+
(1/8)*KK2+(1/6)*KK3) ;

XtempR=XtempR+((1/6)*k1-(2/9)*k2+(8/9)*k3+
(1/6)*k4)*Dt+((1/6)*kk1-(2/9)*kk2+(8/9)*kk3+
(1/6)*kk4)*Winc1+(1/sqrt(3))*((1/6)*K1-(2/9)*K2+
(8/9)*K3-(5/6)*K4)*Winc2+((-1/18)*KK2+(8/9)*KK3+
(-5/6)*KK4)*sqrt(3*Dt);

Xem(j) = Xtemp;
XemM(j) = XtempM;
XemR(j) = XtempR;
Xtruee(j) = Xtrue;
end
if i==1
V=Xem;
U=XemM;
Z=XemR;
Y=Xtruee;
else
V=[V;Xem];
U=[U;XemM];
Z=[Z;XemR];
Y=[Y;Xtruee];
end
emerr(i) = ((V(end)-Y(end))^2);
emerrM(i) = ((U(end)-Y(end))^2);
emerrR(i) = ((Z(end)-Y(end))^2);
end
Vmean=mean(V);
Umean=mean(U);
Zmean=mean(Z);
Ymean=mean(Y);

emerrMEAN(q)=sqrt(mean(emerr));
emerrMMEAN(q)=sqrt(mean(emerrM));
emerrRMEAN(q)=sqrt(mean(emerrR));

DDt(q)=Dt;
end

plot([DDt],[emerrMEAN],'-b',[DDt],[emerrMMEAN],'-
g',[DDt],[emerrRMEAN],'-k'),hold off;
h=legend('em','mil','rk',3);
set(h,'Interpreter','none');
xlabel('delta t','FontSize',12)
ylabel('RMSE','FontSize',16,'Rotation',0,'HorizontalAlignment','right')
title('RMSE vs perubahan delta t dengan T=1 untuk setiap
metode','FontSize',10)

```


Listing Program 4 untuk Gambar 4.4

```

% (RMSE vs [0,T])
% SDE is  $dX = (\mu - D)X dt + \text{vol}X dW$ ,  $X(0) = X_{\text{zero}}$ ,
% where  $\mu = 0.284349207$ ;  $D = 0.02546257$ ;  $\text{vol} = 0.187010224$ ;  $X_{\text{zero}} = 58.91$ ;
% Discretized Brownian path over [0,T]
% Numerical Methods uses timestep  $R*dt = 2^{(-8)}$ .
clear;clc;
randn('state',sum(clock*100))
rand('state',sum(clock*1000))
mu = 0.284349207; D = 0.02546257; vol = 0.187010224; Xzero = 58.91;
% problem parameters
p=0;

for q = 1:10
    p=p+1;
    T = p; N = p*4*256; dt = 1/(4*256); M=1000;
    R = 4; Dt = R*dt; L = N/R; % L EM steps of size Dt = R*dt
    for i = 1:M
        Xtrue = Xzero;
        Xtemp = Xzero;
        XtempM = Xzero;
        XtempR = Xzero;
        dW1 = sqrt(dt)*randn(1,p*N); % Brownian increments
        dW2 = sqrt(dt)*rand(1,p*N); % Brownian increments
        W1=cumsum(dW1,2);
        W2=cumsum(dW2,2);
        for j = 1:L
            Winc1 = sum(dW1(R*(j-1)+1:R*j));
            Winc2 = sum(dW2(R*(j-1)+1:R*j));
            Xtrue = Xtrue * exp((mu-D-(vol^2)/2)*Dt + vol*Winc1);
            Xtemp = Xtemp + Dt*(mu-D)*Xtemp + vol*Xtemp*Winc1;
            XtempM = XtempM + Dt*(mu-D)*XtempM + vol*XtempM*Winc1 +
                0.5*vol^2*XtempM*((Winc1^2)-Dt);

            k1=(mu-D)*XtempR ;
            kk1=vol*XtempR ;
            K1=vol*XtempR ;
            KK1=vol*XtempR ;

            k2=(mu-D)*(XtempR+Dt*((1/2)*k1)+Winc1*((1/2)*kk1)+
                (Winc2/sqrt(3))*((1/2)*K1)) ;
            kk2=vol*(XtempR+Dt*((1/2)*k1)+Winc1*((1/2)*kk1)+
                (sqrt(3*Dt))*((-1)*KK1)) ;
            K2=vol*(XtempR+Dt*((1/2)*k1)+(sqrt(3*Dt))*((-1)*KK1)) ;
            KK2=vol*(XtempR+(sqrt(3*Dt))*((-1)*KK1)) ;

            k3=(mu-D)*(XtempR+Dt*((1/4)*k1+(1/4)*k2)+
                Winc1*((1/4)*kk1+(1/4)*kk2)+(Winc2/sqrt(3))*((1/2)*K2));
            kk3=vol*(XtempR+Dt*((1/4)*k1+(1/4)*k2)+
                Winc1*((1/4)*kk1+(1/4)*kk2)+(sqrt(3*Dt))*

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((-13/32)*KK1+(5/32)*KK2) ) ;
K3=vol*(XtempR+Dt*((1/4)*k1+(1/4)*k2)+(sqrt(3*Dt))*
((-13/32)*KK1+(5/32)*KK2) ) ;
KK3=vol*(XtempR+(sqrt(3*Dt))*((-13/32)*KK1+(5/32)*KK2) );

k4=(mu-D)*(XtempR+Dt*((1/3)*k1+(-2)*k2+
(8/3)*k3)+Winc1*((1/3)*kk1+(-2)*kk2+
(8/3)*kk3)+(Winc2/sqrt(3))*((1)*K3) ) ;
kk4=vol*(XtempR+Dt*((1/3)*k1+(-2)*k2+
(8/3)*k3)+Winc1*((1/3)*kk1+(-2)*kk2+
(8/3)*kk3)+(sqrt(3*Dt))*((-7/24)*KK1+
(1/8)*KK2+(1/6)*KK3) ) ;
K4=vol*(XtempR+Dt*((1/3)*k1+(-2)*k2+
(8/3)*k3)+(sqrt(3*Dt))*((-7/24)*KK1+
(1/8)*KK2+(1/6)*KK3) ) ;
KK4=vol*(XtempR+(sqrt(3*Dt))*((-7/24)*KK1+
(1/8)*KK2+(1/6)*KK3) ) ;

XtempR=XtempR+(1/6)*k1-(2/9)*k2+
(8/9)*k3+(1/6)*k4)*Dt+(1/6)*kk1-(2/9)*kk2+
(8/9)*kk3+(1/6)*kk4)*Winc1+(1/sqrt(3))*((1/6)*
K1-(2/9)*K2+(8/9)*K3-(5/6)*K4)*Winc2+((-1/18)*KK2+
(8/9)*KK3+(-5/6)*KK4)*sqrt(3*Dt);

Xem(j) = Xtemp;
XemM(j) = XtempM;
XemR(j) = XtempR;
Xtruee(j) = Xtrue;
end
if i==1
V=Xem;
U=XemM;
Z=XemR;
Y=Xtruee;
else
V=[V;Xem];
U=[U;XemM];
Z=[Z;XemR];
Y=[Y;Xtruee];
end
emerr(i) = ((V(end)-Y(end))^2);
emerrM(i) = ((U(end)-Y(end))^2);
emerrR(i) = ((Z(end)-Y(end))^2);
end
Vmean=mean(V);
Umean=mean(U);
Zmean=mean(Z);
Ymean=mean(Y);

emerrMEAN(q)=sqrt(mean(emerr));
emerrMMEAN(q)=sqrt(mean(emerrM));
emerrRMEAN(q)=sqrt(mean(emerrR));
TT(q)=T;
end

```

```
plot([TT],[emerrMEAN],'-b',[TT],[emerrMMEAN],'-  
g',[TT],[emerrRMEAN],'-k'),hold off;  
h=legend('em','mil','rk',3);  
set(h,'Interpreter','none');  
xlabel('T','FontSize',12)  
ylabel('RMSE','FontSize',16,'Rotation',0,'HorizontalAlignment','right')  
title('RMSE vs perubahan T (panjang interval) untuk setiap metode  
dengan delta t = 1/2^8','FontSize',10)
```



LAMPIRAN 2

Data Harga Saham MCD 2005, 2006, 2007, 2008

Tanggal	Harga Saham (\$)	2/17/2005	32,29	04/11/2005	30,8
		2/18/2005	32,33	04/12/2005	30,9
12/31/2004	32,06	2/22/2005	31,95	4/13/2005	31,22
01/03/2005	31,82	2/23/2005	32,44	4/14/2005	30,76
01/04/2005	32,08	2/24/2005	32,65	4/15/2005	30,3
01/05/2005	31,83	2/25/2005	32,98	4/18/2005	30,1
01/06/2005	32,08	2/28/2005	33,08	4/19/2005	30,18
01/07/2005	31,87	03/01/2005	33,33	4/20/2005	29,94
01/10/2005	31,67	03/02/2005	33,28	4/21/2005	29,85
01/11/2005	31,1	03/03/2005	33,41	4/22/2005	30,06
01/12/2005	31,34	03/04/2005	33,96	4/25/2005	30,28
1/13/2005	30,89	03/07/2005	34,21	4/26/2005	30
1/14/2005	31,31	03/08/2005	33,48	4/27/2005	30,16
1/18/2005	31,6	03/09/2005	32,53	4/28/2005	29,61
1/19/2005	31,62	03/10/2005	32,75	4/29/2005	29,31
1/20/2005	31,45	03/11/2005	32,59	05/02/2005	29,57
1/21/2005	31,25	3/14/2005	32,96	05/03/2005	29,8
1/24/2005	31,74	3/15/2005	32,43	05/04/2005	30,13
1/25/2005	31,94	3/16/2005	32,32	05/05/2005	29,94
1/26/2005	31,99	3/17/2005	31,8	05/06/2005	29,38
1/27/2005	32,12	3/18/2005	31,9	05/09/2005	30,12
1/28/2005	32	3/21/2005	31,68	05/10/2005	30,1
1/31/2005	32,39	3/22/2005	31,45	05/11/2005	29,85
02/01/2005	31,98	3/23/2005	31,45	05/12/2005	29,78
02/02/2005	31,77	3/24/2005	31,58	5/13/2005	29,65
02/03/2005	32,06	3/28/2005	31,53	5/16/2005	29,88
02/04/2005	32,57	3/29/2005	31,02	5/17/2005	29,97
02/07/2005	32,78	3/30/2005	31,65	5/18/2005	30,58
02/08/2005	32,42	3/31/2005	31,14	5/19/2005	30,97
02/09/2005	31,97	04/01/2005	31	5/20/2005	30,94
02/10/2005	32,1	04/04/2005	30,99	5/23/2005	31,32
02/11/2005	32,25	04/05/2005	31,21	5/24/2005	30,87
2/14/2005	32,61	04/06/2005	31,49	5/25/2005	30,89
2/15/2005	33,16	04/07/2005	31,47	5/26/2005	31,48
2/16/2005	32,6	04/08/2005	31,14	5/27/2005	31,26

5/31/2005	30,94	7/28/2005	30,28	9/26/2005	33,26
06/01/2005	31,02	7/29/2005	31,17	9/27/2005	33,01
06/02/2005	31,12	08/01/2005	31,18	9/28/2005	33,1
06/03/2005	30,51	08/02/2005	31,48	9/29/2005	33,48
06/06/2005	30,41	08/03/2005	31,62	9/30/2005	33,49
06/07/2005	29,57	08/04/2005	31,2	10/03/2005	33,87
06/08/2005	29,23	08/05/2005	31,3	10/04/2005	32,88
06/09/2005	28,98	08/08/2005	32,14	10/05/2005	32,85
06/10/2005	29,53	08/09/2005	32,44	10/06/2005	32,73
6/13/2005	29,11	08/10/2005	32,7	10/07/2005	32,22
6/14/2005	29,3	08/11/2005	34,69	10/10/2005	32,34
6/15/2005	28,95	08/12/2005	33,25	10/11/2005	32,34
6/16/2005	29,13	8/15/2005	33,6	10/12/2005	31,67
6/17/2005	29	8/16/2005	33,17	10/13/2005	32,05
6/20/2005	29,06	8/17/2005	33,87	10/14/2005	32,32
6/21/2005	29,04	8/18/2005	33,39	10/17/2005	32,7
6/22/2005	29,02	8/19/2005	33,38	10/18/2005	32,47
6/23/2005	28,57	8/22/2005	33,29	10/19/2005	33,69
6/24/2005	28,28	8/23/2005	33,04	10/20/2005	32,4
6/27/2005	28,16	8/24/2005	32,98	10/21/2005	32,48
6/28/2005	28,24	8/25/2005	33,3	10/24/2005	33,12
6/29/2005	27,91	8/26/2005	33,48	10/25/2005	33
6/30/2005	27,75	8/29/2005	33,17	10/26/2005	32,31
07/01/2005	27,94	8/30/2005	32,4	10/27/2005	31,55
07/05/2005	27,97	8/31/2005	32,45	10/28/2005	32,29
07/06/2005	27,7	09/01/2005	31,55	10/31/2005	31,6
07/07/2005	28	09/02/2005	31,9	11/01/2005	31,77
07/08/2005	28,65	09/06/2005	32,66	11/02/2005	32,26
07/11/2005	28,97	09/07/2005	33,7	11/03/2005	33,23
07/12/2005	29,16	09/08/2005	33,37	11/04/2005	33,43
7/13/2005	29,59	09/09/2005	34,14	11/07/2005	33,7
7/14/2005	29,6	09/12/2005	33,8	11/08/2005	34
7/15/2005	30,99	9/13/2005	33,12	11/09/2005	33,33
7/18/2005	30,9	9/14/2005	32,36	11/11/2005	33,8
7/19/2005	30,85	9/15/2005	33,45	11/14/2005	33,93
7/20/2005	30,9	9/16/2005	34,24	11/15/2005	33,31
7/21/2005	30,78	9/19/2005	33,5	11/16/2005	32,8
7/22/2005	30,94	9/20/2005	32,62	11/17/2005	33,19
7/25/2005	30,62	9/21/2005	31,42	11/18/2005	33,09
7/26/2005	30,36	9/22/2005	33,09	11/21/2005	33,07
7/27/2005	30,08	9/23/2005	32,64	11/22/2005	32,99

11/23/2005	33,71	1/25/2006	35,16	3/24/2006	34,7
11/25/2005	33,46	1/26/2006	34,94	3/27/2006	34,55
11/28/2005	33,95	1/27/2006	35,05	3/28/2006	34,31
11/29/2005	33,93	1/30/2006	35,02	3/29/2006	34,6
11/30/2005	33,85	1/31/2006	35,01	3/30/2006	34,55
12/01/2005	35,33	02/01/2006	35,67	3/31/2006	34,36
12/02/2005	34,91	02/02/2006	35,45	04/03/2006	34,73
12/05/2005	34,57	02/03/2006	35,97	04/04/2006	34,66
12/06/2005	35,16	02/06/2006	36,13	04/05/2006	34,81
12/07/2005	35,26	02/07/2006	36,19	04/06/2006	34,6
12/08/2005	34,82	02/08/2006	36,36	04/07/2006	34,88
12/09/2005	34,84	02/09/2006	36,3	04/10/2006	35,35
12/12/2005	34,47	02/10/2006	36,33	04/11/2006	35,55
12/13/2005	35,27	2/13/2006	36,36	04/12/2006	35,19
12/14/2005	35,5	2/14/2006	36,37	4/13/2006	34,85
12/15/2005	34,98	2/15/2006	36,01	4/17/2006	34,32
12/16/2005	34,75	2/16/2006	36,37	4/18/2006	34,48
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12/21/2005	34,44	2/22/2006	35,95	4/21/2006	34,6
12/22/2005	34,58	2/23/2006	35,59	4/24/2006	34,26
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01/03/2006	33,52	03/03/2006	34,85	05/02/2006	34,41
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01/05/2006	33,86	03/07/2006	34,64	05/04/2006	34,85
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01/10/2006	34,74	03/10/2006	34,65	05/09/2006	35,83
01/11/2006	35,34	3/13/2006	34,32	05/10/2006	35,96
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1/13/2006	34,47	3/15/2006	34,77	05/12/2006	34,88
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1/20/2006	35,86	3/21/2006	34,9	5/18/2006	34,44
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5/25/2006	33,26	7/25/2006	34,76	9/21/2006	38,34
5/26/2006	32,92	7/26/2006	34,45	9/22/2006	38,21
5/30/2006	32,72	7/27/2006	34,73	9/25/2006	38,85
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06/09/2006	33,38	08/08/2006	35,16	10/05/2006	39,8
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6/28/2006	31,97	8/25/2006	35,23	10/24/2006	42,25
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6/30/2006	33,6	8/29/2006	36,08	10/26/2006	42,11
07/03/2006	33,97	8/30/2006	36,15	10/27/2006	41,47
07/05/2006	33,76	8/31/2006	35,9	10/30/2006	41,92
07/06/2006	33,69	09/01/2006	36,76	10/31/2006	41,92
07/07/2006	33,18	09/05/2006	36,65	11/01/2006	41,86
07/10/2006	33,68	09/06/2006	36,22	11/02/2006	42,05
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11/28/2006	41,4	1/30/2007	43,77	3/29/2007	44,87
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11/30/2006	41,97	02/01/2007	44,48	04/02/2007	44,82
12/01/2006	42,08	02/02/2007	44,54	04/03/2007	45,26
12/04/2006	42,5	02/05/2007	44,53	04/04/2007	45,23
12/05/2006	42,75	02/06/2007	44,77	04/05/2007	45,78
12/06/2006	42,96	02/07/2007	44,72	04/09/2007	46,49
12/07/2006	43,28	02/08/2007	44,35	04/10/2007	46,31
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12/11/2006	43,58	02/12/2007	44,73	04/12/2007	46,63
12/12/2006	43,04	2/13/2007	44,9	4/13/2007	47,64
12/13/2006	43,59	2/14/2007	45,02	4/16/2007	48,1
12/14/2006	43,69	2/15/2007	44,98	4/17/2007	49,01
12/15/2006	43,41	2/16/2007	45,32	4/18/2007	48,88
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01/04/2007	43,54	03/06/2007	43,1	05/03/2007	49,91
01/05/2007	43,54	03/07/2007	43,1	05/04/2007	49,92
01/08/2007	43,71	03/08/2007	43,64	05/07/2007	49,5
01/09/2007	43,79	03/09/2007	44,15	05/08/2007	49,32
01/10/2007	44,26	03/12/2007	44,67	05/09/2007	49,84
01/11/2007	44,51	3/13/2007	43,48	05/10/2007	50
01/12/2007	44,22	3/14/2007	43,65	05/11/2007	50,65
1/16/2007	44,57	3/15/2007	43,47	5/14/2007	50,63
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5/24/2007	50,96	7/24/2007	51,55	9/20/2007	54,87
5/25/2007	50,9	7/25/2007	50,96	9/21/2007	54,8
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06/12/2007	51,48	08/09/2007	49,93	10/08/2007	56,87
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6/22/2007	50,42	8/21/2007	48,47	10/18/2007	56,79
6/25/2007	51,3	8/22/2007	49,36	10/19/2007	56,42
6/26/2007	51,75	8/23/2007	49,85	10/22/2007	56,02
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6/29/2007	50,76	8/28/2007	48,64	10/25/2007	58,07
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11/14/2007	56,7	01/15/2008	53,76	03/14/2008	54,78
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11/16/2007	58,13	01/17/2008	51,98	03/18/2008	54,85
11/19/2007	58,6	01/18/2008	52,4	03/19/2008	53,66
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12/12/2007	61,66	02/12/2008	56,37	04/11/2008	55,4
12/13/2007	61,51	02/13/2008	56,64	04/14/2008	55,54
12/14/2007	61,16	02/14/2008	55,58	04/15/2008	55,96
12/17/2007	59,76	02/15/2008	55,3	04/16/2008	57,18
12/18/2007	59,83	02/19/2008	55,67	04/17/2008	57,33
12/19/2007	58,85	02/20/2008	56,2	04/18/2008	58,3
12/20/2007	58,79	02/21/2008	55,23	04/21/2008	58,67
12/21/2007	60,03	02/22/2008	55,69	04/22/2008	58,35
12/24/2007	60,31	02/25/2008	56,05	04/23/2008	58,69
12/26/2007	59,88	02/26/2008	56,45	04/24/2008	59,58
12/27/2007	59,19	02/27/2008	55,33	04/25/2008	59,67
12/28/2007	59,5	02/28/2008	54,62	04/28/2008	59,59
12/31/2007	58,91	02/29/2008	54,11	04/29/2008	60,2
01/02/2008	58,1	03/03/2008	53,16	04/30/2008	59,58
01/03/2008	57,93	03/04/2008	53,63	05/01/2008	60,92
01/04/2008	57,05	03/05/2008	53,94	05/02/2008	60,95
01/07/2008	58,03	03/06/2008	53,04	05/05/2008	60,87
01/08/2008	57,08	03/07/2008	52,27	05/06/2008	60,49
01/09/2008	57,47	03/10/2008	53,8	05/07/2008	59,38
01/10/2008	58,17	03/11/2008	54,25	05/08/2008	59,77

05/09/2008	59,24	07/09/2008	59,25	09/05/2008	60,3
05/12/2008	60,87	07/10/2008	58,44	09/08/2008	62,42
05/13/2008	61,17	07/11/2008	57,32	09/09/2008	63,19
05/14/2008	60,44	07/14/2008	58,09	09/10/2008	63,2
05/15/2008	60,86	07/15/2008	58,56	09/11/2008	64,56
05/16/2008	60,53	07/16/2008	60,16	09/12/2008	64,06
05/19/2008	60,45	07/17/2008	60,37	09/15/2008	63,72
05/20/2008	59,68	07/18/2008	60,44	09/16/2008	64,29
05/21/2008	58,78	07/21/2008	59,75	09/17/2008	62,52
05/22/2008	58,53	07/22/2008	60,12	09/18/2008	63,96
05/23/2008	57,73	07/23/2008	59,66	09/19/2008	63,98
05/27/2008	58,11	07/24/2008	58,37	09/22/2008	62,57
05/28/2008	58,69	07/25/2008	58,65	09/23/2008	61,78
05/29/2008	59,48	07/28/2008	57,79	09/24/2008	61,43
05/30/2008	59,32	07/29/2008	59,7	09/25/2008	62,27
06/02/2008	58,55	07/30/2008	60,45	09/26/2008	63,2
06/03/2008	57,56	07/31/2008	59,79	09/29/2008	60,16
06/04/2008	57,98	08/01/2008	59,77	09/30/2008	61,7
06/05/2008	58,05	08/04/2008	60,55	10/01/2008	63,66
06/06/2008	56,95	08/05/2008	62,33	10/02/2008	61,88
06/09/2008	59,31	08/06/2008	62,14	10/03/2008	60,23
06/10/2008	59,77	08/07/2008	61,86	10/06/2008	57,15
06/11/2008	58,75	08/08/2008	65,67	10/07/2008	54,97
06/12/2008	59,34	08/11/2008	65,95	10/08/2008	53,41
06/13/2008	59,95	08/12/2008	63,94	10/09/2008	52,08
06/16/2008	59,94	08/13/2008	62,78	10/10/2008	53,35
06/17/2008	59,21	08/14/2008	63,6	10/13/2008	57,25
06/18/2008	58,21	08/15/2008	63,63	10/14/2008	56,02
06/19/2008	58,59	08/18/2008	63,29	10/15/2008	51,55
06/20/2008	57,4	08/19/2008	62,46	10/16/2008	54,46
06/23/2008	57,01	08/20/2008	62,43	10/17/2008	53,8
06/24/2008	57,02	08/21/2008	62,31	10/20/2008	56,84
06/25/2008	58,05	08/22/2008	63,42	10/21/2008	55,13
06/26/2008	56,45	08/25/2008	62,08	10/22/2008	54,18
06/27/2008	56,5	08/26/2008	62,13	10/23/2008	55,58
06/30/2008	56,22	08/27/2008	62,08	10/24/2008	53,06
07/01/2008	57,29	08/28/2008	62,89	10/27/2008	51,76
07/02/2008	57,43	08/29/2008	62	10/28/2008	56,62
07/03/2008	57,19	09/02/2008	62,91	10/29/2008	57,18
07/07/2008	57,36	09/03/2008	61,72	10/30/2008	57,87
07/08/2008	58,52	09/04/2008	60,02	10/31/2008	57,93

11/03/2008	57,03	11/10/2008	56,48	11/17/2008	55,61
11/04/2008	57,78	11/11/2008	56,29	11/18/2008	56,51
11/05/2008	56	11/12/2008	54,02	11/19/2008	55,44
11/06/2008	54,17	11/13/2008	56,25	11/20/2008	52,91
11/07/2008	55,47	11/14/2008	56,13		

Data Dividen MCD 2005, 2006, 2007, dan 2008

Tanggal	Dividen (\$)
11/10/2005	0,67
11/13/2006	1
11/13/2007	1,5
02/28/2008	0,375
06/05/2008	0,375
10/28/2008	0,375