$\boxed{9.34}$ A plot of the squared error is only a rough approximation to the learning curve in the sense that $E[e^2(k)] \approx e^2(k)$. Write a MATLAB script that uses the FDSP toolbox function *f_lms* to identify the following system. For the input use $N = 500$ samples of white noise uniformly distributed over $[-1, 1]$, and for the filter order use $m = 30$.

$$H(z) = \frac{z}{z^3 + 0.7z^2 - 0.8z - 0.56}$$

(a) Use a step size μ than corresponds to 0.1 of the upper bound in (9.4.16). Print the step size used.

(b) Compute and print the mean square error time constant in (9.4.29), but in units of iterations.

(c) Construct and plot a learning curve by performing the system identification $M = 50$ times with a different white noise input used each time. Plot the average of the M $e^2(k)$ versus k curves and draw vertical lines at each integer multiple of the time constant.

Solution

```
% Problem 9.34

% Initialize

clear
clc
m = f_prompt ('Enter filter order m',0,60,30);
N = f_prompt ('Enter number of points N',1,2000,500);
c = f_prompt ('Enter magnitude of noise c',0,4,1);
M = f_prompt ('Enter number of iterations M',1,100,50);
b = [0 0 1]
a = [1 0.7 -0.8 -0.56]

% Compute step size

P_x = (1/N)*sum(x.^2);
mu = 0.1/((m+1)*P_x)

% Compute MSE time constant

lambda_min = P_x;
T = 1;
tau_mse = T/(4*mu*lambda_min)

% Find learning curve

E = zeros(N,1);
```

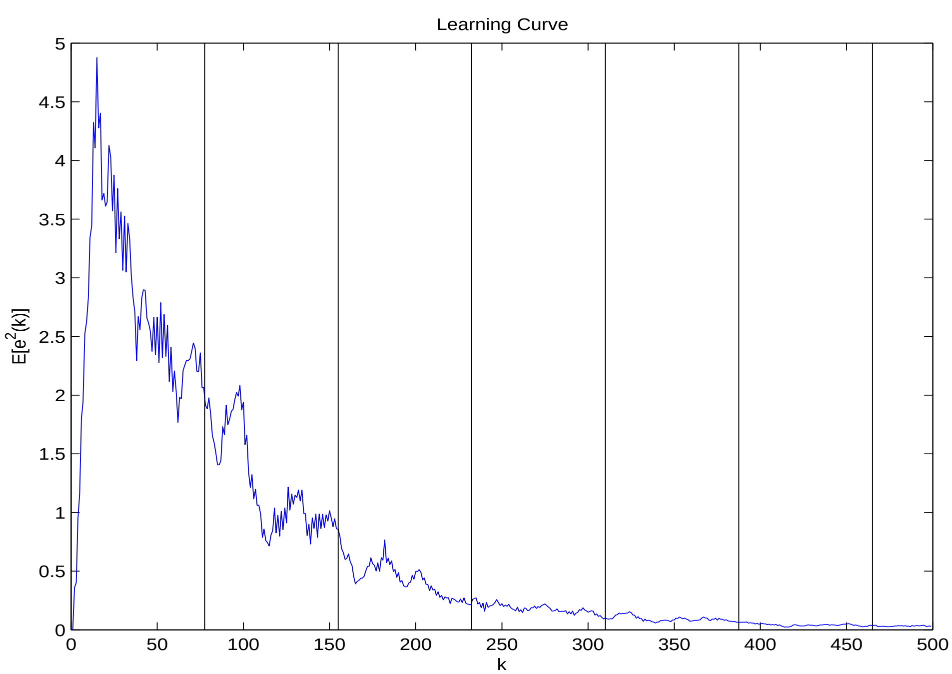
```
for i = 1 : M
   x = f_randu (N,1,-c,c);
   d = filter (b,a,x);
   [w,e] = f_lms (x,d,m,mu);
   E = E + e.^2;
end
E = E/M;

% Plot learning curve showing time constants

figure
k = 0 : N-1;
plot (k,E)
f_labels ('Learning Curve','k','E[e^2(k)]')
hold on
r = floor (N/tau_mse);
ylim = get (gca,'Ylim');
for i = 1 : r
    plot ([i*tau_mse,i*tau_mse],[ylim(1),ylim(2)],'k')
end
```

(a)
```
mu =
        0.0100
```

(b)
```
tau_mse =
      77.5000
```



(c) Learning Curve Based on $M = 50$ Identifications