Solve a. and b. in GNU Octave or a similar software.

```
num = [0 0 2.25];
den = [1,0.5,2.25];
H=tf(num, den); %assign transfer function to a variable

[freq damp_ratio] = damp(H); %calculate damping ratio and
natural frequency

fprintf('Damping Ratio: %f\n', damp_ratio(1));
fprintf('Natural Frequency: %f\n', freq(1));

%calculate overshoot and peak time
t=0:0.1:26;
[y,x,t]=step(num,den,t);

for i=2:1:260
     if y(i)<=y(i-1)
         break;
    end
end

Mp=y(i)-y(260);
Tp=t(i);

fprintf('Overshoot: %f\n', Mp);
fprintf('Peak Time: %f\n', Tp);

%calculate settling time
ts=0.02;
i=2;
for i=260:-1:2
    if (abs(y(i)-y(260)))>=0.02
        break;
    end
end
Ts=t(i);

fprintf('Settling Time: %f\n', Ts);
```

Output:

```
Damping Ratio: 0.166667
Natural Frequency: 1.500000
Overshoot: 0.585657
Peak Time: 2.200000
Settling Time: 15.300000
```

b. Position Error Constant, Velocity Error Constant and Acceleration Error Constant.

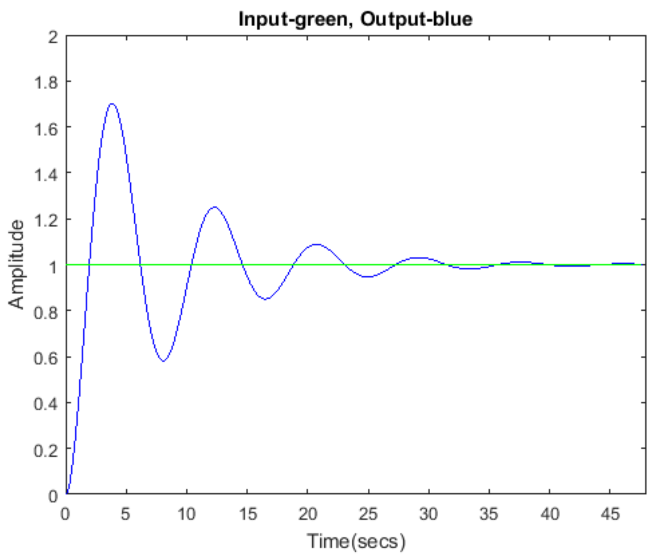
```
%% Assign values to variables
num =10*poly([-1,-2]);
den=[1 12 47 60 0 0];
Gs=tf(num,den);

T=0.1;
Gz=c2d(Gs,T,'zoh');
Tz=feedback(Gz,1);

r=pole(Tz);
M=abs(r);

%% Calculate Kp
Kp=dcgain(Gz)

%% Calculate Kv
GzKv=Gz*(1/T)*tf([1 -1],[1 0],T);
GzKv=minreal(GzKv,0.00001);
Kv=dcgain(GzKv)

%% Calculate Ka
GzKa=Gz*(1/T^2)*tf([1 -2 1],[1 0 0],T);
GzKa=minreal(GzKa,0.00001);
Ka=dcgain(GzKa)

%% Output the calculated data
fprintf('Kp : %f\n', Kp);
fprintf('Kv : %f\n', Kv);
fprintf('Ka : %f\n', Ka);
```

Output:

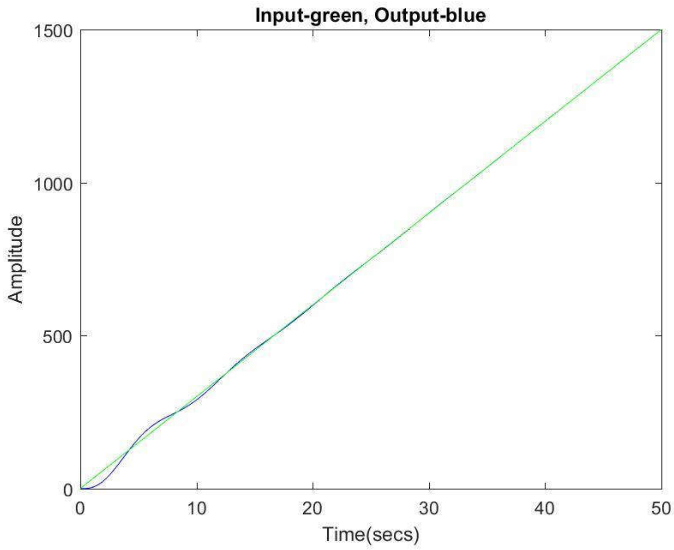
```
Kp : 403772197853.537476
Kv : -224317887696.404327
Ka : 0.333333
```

c. The steady-state error for inputs 30u(t), 30tu(t) and $30t^2u(t)$:

```
%% R(s) = 30u(t)
K=10;
s = tf('s');
G = (K*(s+1)*(s+3))/((s*s)*(s+3)*(s+4)*(s+5));
sys_cl = feedback(G,1);
[y,t] = step(sys_cl);
u =( 30 * ones(size(t)));

figure(1);
plot(t,y,'b',t,u,'g');

axis([0,48,0,2]);
xlabel('Time(secs)');
ylabel('Amplitude');
title('Input-green, Output-blue');
```




```
%% R(s) = 30tu(t)
figure(2);

t = 0:0.1:50;
u = 30*t;
[y,t,x] = lsim(sys_cl,u,t);
plot(t,y,'b',t,u,'g')
xlabel('Time(secs)')
ylabel('Amplitude')
title('Input-green, Output-blue');
```




```
%% R(s)= 30t^2 u(t)
figure(3);

t = 0:0.1:20;
u = 30*0.5*t.*t;
[y,x] = lsim(sys_cl,u,t);
plot(t,y,'b',t,u,'g');
xlabel('Time(secs)');
ylabel('Amplitude');
title('Input-green, Output-blue');
```