Table of Contents

MAE 150 HW 4 Problem 1 & 2

```
clear
close all

% 5th Degree Polynomial Fit
y = [0 0.1 0.3 0.7 1.2 1.8 2.5 3.3 4.1 5 5.9 6.7 7.5 8.2 8.8 9.3 9.7 9.9 10]';
theta = (0:5:90)';

M = length(y);
x = theta;
A = [        M    sum(x) sum(x.^2) sum(x.^3) sum(x.^4) sum(x.^5);
        sum(x) sum(x.^2) sum(x.^3) sum(x.^4) sum(x.^5) sum(x.^6);
     sum(x.^2) sum(x.^3) sum(x.^4) sum(x.^5) sum(x.^6) sum(x.^7);
     sum(x.^3) sum(x.^4) sum(x.^5) sum(x.^6) sum(x.^7) sum(x.^8);
     sum(x.^4) sum(x.^5) sum(x.^6) sum(x.^7) sum(x.^8) sum(x.^9);
     sum(x.^5) sum(x.^6) sum(x.^7) sum(x.^8) sum(x.^9) sum(x.^10)];
b = [      sum(y);
        sum(y.*x);
     sum(y.*x.^2);
     sum(y.*x.^3);
     sum(y.*x.^4);
     sum(y.*x.^5)];

a = A\b;
```

Define functions

```
dtheta = 1;
omega = 250*360/60;
R_f = 6/10^3;
R_b = 45/10^3;
R_0 = (R_f + R_b);

% 5th Degree Polynomial Rise
beta = 90;
theta = (0:dtheta:beta)';
y_1 = (a(1) + a(2)*theta + a(3)*theta.^2 + a(4)*theta.^3 + a(5)*theta.^4 +
 a(6)*theta.^5)/10^3;
v_1 = (a(2)*omega + 2*a(3)*omega*theta + 3*a(4)*omega*theta.^2 +
 4*a(5)*omega*theta.^3 + 5*a(6)*omega*theta.^4)/10^3;
dy1dth = v_1/omega*180/pi;
```

```
phi_1 = atand(dy1dth./(R_0 + y_1));

% Dwell
beta = 120 - 90;
theta = (0:dtheta:beta)';
L = 10/10^3;
y_2 = L*ones(length(theta),1);
v_2 = zeros(length(theta),1);
dy2dth = v_2/omega*180/pi;
phi_2 = atand(dy2dth./(R_0 + y_2));

% Harmonic Rise
beta = 180 - 120;
theta = (0:dtheta:beta)';
L = (20 - 10)/10^3;
y_3 = L/2*(1-cos(pi*theta/beta)) + 10/10^3;
v_3 = L/2*pi*omega/beta*sin(pi*theta/beta);
dy3dth = v_3/omega*180/pi;
phi_3 = atand(dy3dth./(R_0 + y_3));

% Dwell
beta = 210 - 180;
theta = (0:dtheta:beta)';
L = 20/10^3;
y_4 = L*ones(length(theta),1);
v_4 = zeros(length(theta),1);
dy4dth = v_4/omega*180/pi;
phi_4 = atand(dy4dth./(R_0 + y_4));

% Cycloidal Rise
beta = 280 - 210;
theta = (0:dtheta:beta)';
L = (32 - 20)/10^3;
y_5 = L*(theta/beta - 1/(2*pi)*sin(2*pi*theta/beta)) + 20/10^3;
v_5 = L*omega/beta*(1 - cos(2*pi*theta/beta));
dy5dth = v_5/omega*180/pi;
phi_5 = atand(dy5dth./(R_0 + y_5));

% Dwell
beta = 300 - 280;
theta = (0:dtheta:beta)';
L = 32/10^3;
y_6 = L*ones(length(theta),1);
v_6 = zeros(length(theta),1);
dy6dth = v_6/omega*180/pi;
phi_6 = atand(dy6dth./(R_0 + y_6));

% 3-4-5 Polynomial Fall
beta = 360 - 300;
theta = (0:dtheta:beta)';
L = 32/10^3;
y_7 = L - L*(10*theta.^3/beta^3 - 15*theta.^4/beta^4 + 6*theta.^5/beta^5);
v_7 = -L*(30*omega*theta.^2/beta^3 - 60*omega*theta.^3/beta^4 +
 30*omega*theta.^4/beta^5);
```

```
dy7dth = v_7/omega*180/pi;
phi_7 = atand(dy7dth./(R_0 + y_7));
```

(a) Plotting Cam Profile

```
theta = (0:dtheta:360)';
y = [0; y_1(2:end-1); y_2(1:end); y_3(2:end); y_4(2:end); y_5(2:end);
 y_6(2:end); y_7(2:end)];
phi = [0; phi_1(2:end-1); phi_2(1:end); phi_3(2:end); phi_4(2:end);
 phi_5(2:end); phi_6(2:end); phi_7(2:end)];
x_p = (R_0+y).*sind(theta);
y_p = (R_0+y).*cosd(theta);
x_c = x_p - R_f*sind(theta-phi);
y_c = y_p - R_f*cosd(theta-phi);

pit = [y_p';
       x_p';
       ones(1,length(theta))];
cam = [y_c';
       x_c';
       ones(1,length(theta))];

color = ('kmbkr');
linewidth = 2;
markersize = 20;
fontsize = 14;

fprintf('Part (a)\n')
figure
plot(0,0,'.','Color',color(1),'MarkerSize',markersize)
hold on
plot(R_b*cosd(theta),R_b*sind(theta),'-','Color',color(2),'LineWidth',linewidth)
plot(pit(1,:),pit(2,:),'--','Color',color(3),'LineWidth',linewidth)
plot(cam(1,:),cam(2,:),color(4),'LineWidth',linewidth)
hold off
grid on
axis equal
axis([-0.08 0.08 -0.09 0.09])
title('(a) Cam Profile')
xlabel('X axis (m)')
ylabel('Y axis (m)')
set(gca,'FontSize',fontsize)
legend('Center of Rotation','Base Circle','Pitch Curve','Cam
 Contour','Location','best')
```

(b) Plotting Rotation

```
fol_ = [R_f*cosd(theta');
        R_f*sind(theta');
        ones(1,length(theta))];

R_cw = [ cosd(60) sind(60) 0;
        -sind(60) cosd(60) 0;
```

```
               0        0 1];

linewidth = 1;
markersize = 10;

fprintf('Part (b)\n')
figure
for i = 1:6
    t_x = pit(1,1+60*(i-1));
    T_x = [1 0 t_x;
           0 1   0;
           0 0   1];
    fol = T_x*fol_;
    angle = 0:60:300;
    subplot(2,3,i)

 plot(0,0,'.','Color',color(1),'MarkerSize',markersize,'LineWidth',linewidth)
    hold on

 plot(R_b*cosd(theta),R_b*sind(theta),'-','Color',color(2),'LineWidth',linewidth)
    plot(pit(1,:),pit(2,:),'--','Color',color(3),'LineWidth',linewidth)
    plot(cam(1,:),cam(2,:),color(4),'LineWidth',linewidth)
    plot(fol(1,:),fol(2,:),color(5),'LineWidth',linewidth)
    hold off
    grid on
    axis equal
    axis([-0.1 0.1 -0.1 0.1])
    title(sprintf('%d deg',angle(i)))
    xlabel('X axis (m)')
    ylabel('Y axis (m)')
    set(gca,'FontSize',fontsize)
    pit = R_cw*pit;
    cam = R_cw*cam;
end

legend('Center of Rotation','Base Circle','Pitch Curve','Cam
 Contour','Follower')
legend("Position", [0.4,0.77,0.25714,0.16548])
sgtitle(sprintf('(b) Cam Rotation\n\n\n
\n'),'fontsize',1.25*fontsize,'fontweight','bold')
```

Problem 2 (a)

```
xyz = [y_p x_p zeros(length(theta),1)];
writematrix(xyz,'cam_profile.txt');
```

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