Appendix 1 MATLAB code for the mathematical formulation of the opening angle with different hinge positions

1. MATLAB code

```
% Create bars with different k and MA.
clc;clear all
syms Xp Yp Xd k x y
assume(Xp>0)
assume(Yp>0)
assume(Xd>0)
assume(k>0)
r = sqrt((Xp-Xd)^2+(Yp-0)^2);
l = k*x;
equ = (l == (sqrt(r^2 - (x-Xp)^2)+Yp));
solution = solve(equ, x);
x = solution(1);
y = k*x;
bc = sqrt((x-Xd)^2 + (y-0)^2);
ab = sqrt((Xp-Xd)^2 + (Yp-0)^2);
ac = sqrt((x-Xp)^2 + (y-Yp)^2);
alpha = acos((ab^2 + ac^2 -bc^2)/(2*ab*ac));

num_row = 2;
num_column = 5;
num_pts = 3;
dist_PD = [0.625, 0.425, 0.225];
interval_k = tand(linspace(5,35,10));
color = cell(1, 3);
color{1} = [1, 0, 0]; % red
color{2} = [1, 0.7, 0];% yellow
color{3} = [0, 0.6, 0];% green
legend_pts = cell(1,3);
legend_pts{1} = 'A';
legend_pts{2} = 'B';
legend_pts{3} = 'C';

alpha_sub = cell(1,3); %The formula of 3 pts.
alpha_sub_simple = cell(1,3);
for i = 1 : num_pts
    alpha_sub{i} = subs(alpha, Yp, 0.05);
    alpha_sub{i} = subs(alpha_sub{i}, Xd, Xp + dist_PD(i));
    alpha_sub{i} = alpha_sub{i}*180/pi;
    alpha_sub_simple{i} = simplify(alpha_sub{i});

end
```


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```
for j = 1:length(interval_k)
    alpha_sub_value = alpha_sub_simple;
    for m = 1: num_pts
        alpha_sub_value{m} = subs(alpha_sub_simple{m}, k, interval_k(j));
        subplot(num_row, num_column, j);
        hold on
        fplot(alpha_sub_value{m}, [0.1 + 0.2 * (m - 1), 0.375 + 0.2 * (m - 1)], 'Color', color{m})
        legend(legend_pts, 'Location', 'northwest');
        legend('boxoff');
    end

    xlabel('Xp');
    ylabel('Angle');
    title([ ' Angle=' , num2str(atan(interval_k(j))*180/pi)]);

end
```


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