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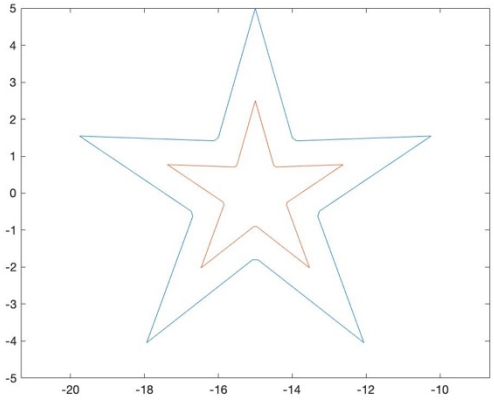
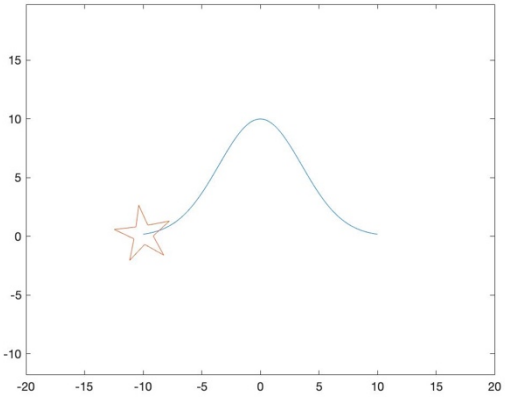
Problem1

Code is in the Matlab file

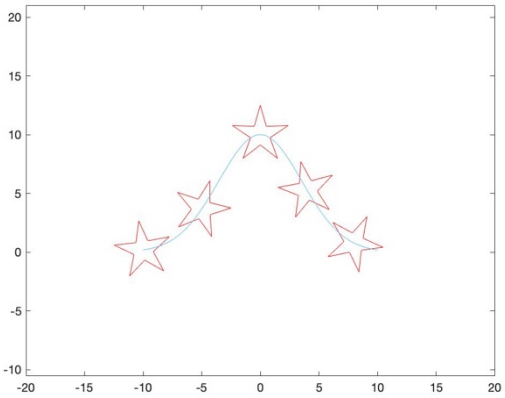
(a)(b)



(c)



（d）



Problem 2

(a) $M = 3(l-1) - 2j$ $l=5$ $j=5$

$M = 3\times4 - 10 = 2$ $\therefore$ DOF $=2$

(b)
$$\begin{cases} x: l_1\cos\theta_1 + l_2\cos(\theta_1+\theta_2) + l_0 - l_3\cos(\theta_3) - l_4\cos(\theta_3+\theta_4) = 0 \\ y: l_1\sin\theta_1 + l_2\sin(\theta_1+\theta_2) - l_3\sin(\theta_3) - l_4\sin(\theta_3+\theta_4) = 0 \end{cases}$$

(c) Unlike 4-bar (DOF $=1$), the 5-bar has 2 degrees of freedom, so we should certain two variables, for example the θ_1 and θ_3 as independent variables

① Define the range of θ_1 and θ_3

② Two for loop eg, to create 2 dimentional ranges, by the constain given fsolve, x_e, y_e can be certain. And the whole movement can be simulated.

Outlook of matlab.

```
for θ1
    for θ3
        F = constain equation with θ1 and θ3
        fsolve(F, 0)
    end
end
```

(d) ① certain the relation ship, such as x_e, y_e, and also v_{xe}, v_{ye}, ($\sqrt{v_e^2 + v_y^2} = 0$) as the constain F we need, with all variables and parameters as Problem 2c. However, the length through l_0 to l_4 change, which indeed increase the DOF of the whole system. We can use more layers "for loop" to "fsolve" the extremum, but we also can use "fminsearch" and "fmincon" to optimizate.

② "fmincon" is a gradient based function to find minimum of constrained nolinear multivarible.

$$\min f(x) \text{ such that } \begin{cases} C(X) \le 0 \\ Ceq(X) \ge 0 \\ AX \le b \\ Aeq \cdot X = beq \end{cases}$$

"fminsearch" find minimum of unconstrained multivariable function using derivative-free method.

$$\min_x f(x)$$

③ Fminsearch do not need to know the gradient bue it can't deal with explicit boundaries, and for large numbers of parameters, it gets inefficient.

In this question, Fmincon is very suitable for bounded optimization, and thus are better given the leg requirement

Problem 3

(a)

$AB: (x-\frac{a}{2})^2+(y+\frac{\sqrt{3}}{3}\frac{a}{2})^2=a^2$

$x^2+y^2-ax+\frac{\sqrt{3}}{3}ay-\frac{2}{3}a^2=0$

$\Rightarrow \rho^2-a\cos\theta\rho+\frac{\sqrt{3}}{3}a\sin\theta\rho-\frac{2}{3}a^2=0 \quad \theta\in(\frac{\pi}{2},\frac{7}{6}\pi)$

$AC: (x+\frac{a}{2})^2+(y+\frac{\sqrt{3}}{3}\frac{a}{2})^2=a^2 \quad \theta\in(-\frac{\pi}{6},\frac{\pi}{2})$

$x^2+y^2+ax+\frac{\sqrt{3}}{3}ay-\frac{2}{3}a^2=0$

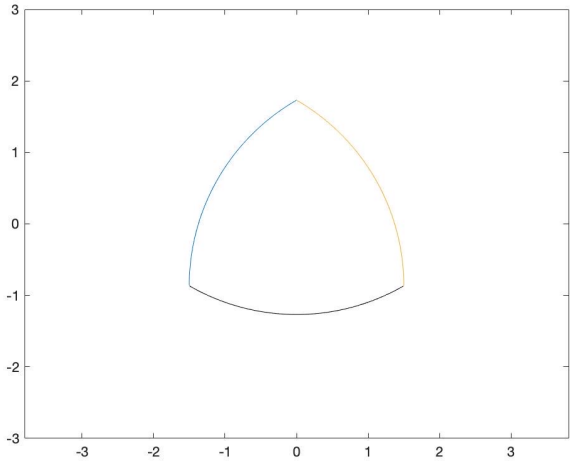
$\Rightarrow \rho^2+a\cos\theta\rho+\frac{\sqrt{3}}{3}a\sin\theta\rho-\frac{2}{3}a^2=0$

$BC: x^2+(y-\frac{2\sqrt{3}}{3}\cdot\frac{a}{2})^2=a^2 \quad \theta\in(-\frac{5\pi}{6},-\frac{\pi}{6})$

$x^2+y^2+\frac{1}{3}a^2-\frac{2\sqrt{3}}{3}ay-a^2=0$

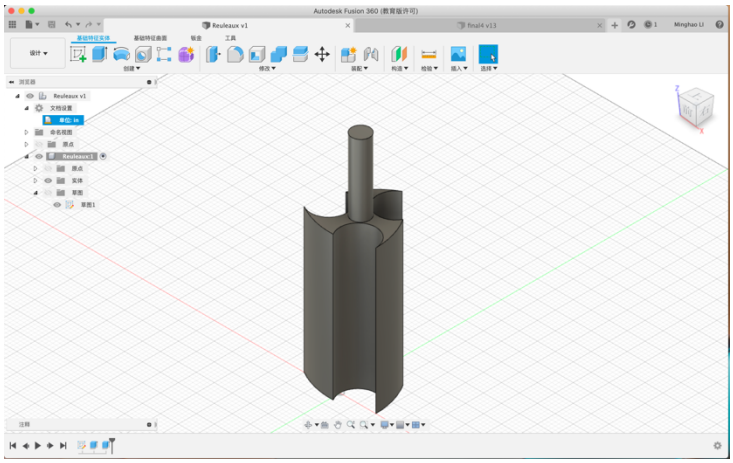
$\Rightarrow \rho^2-\frac{2\sqrt{3}}{3}a\rho\sin\theta-\frac{2}{3}a^2=0$

(b)



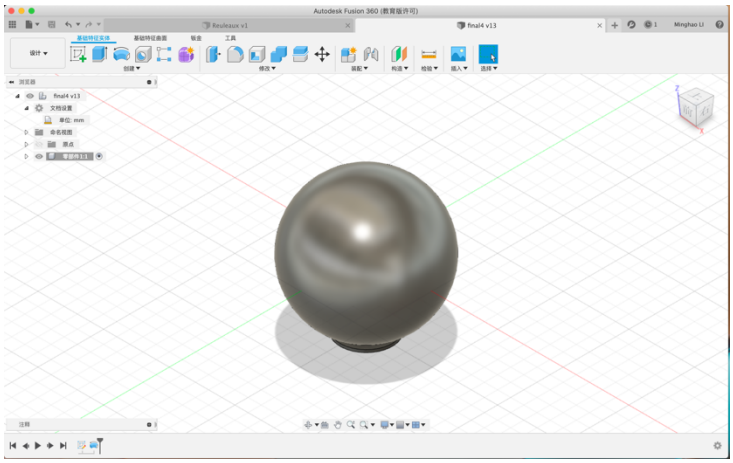
c

https://a360.co/37ivda5



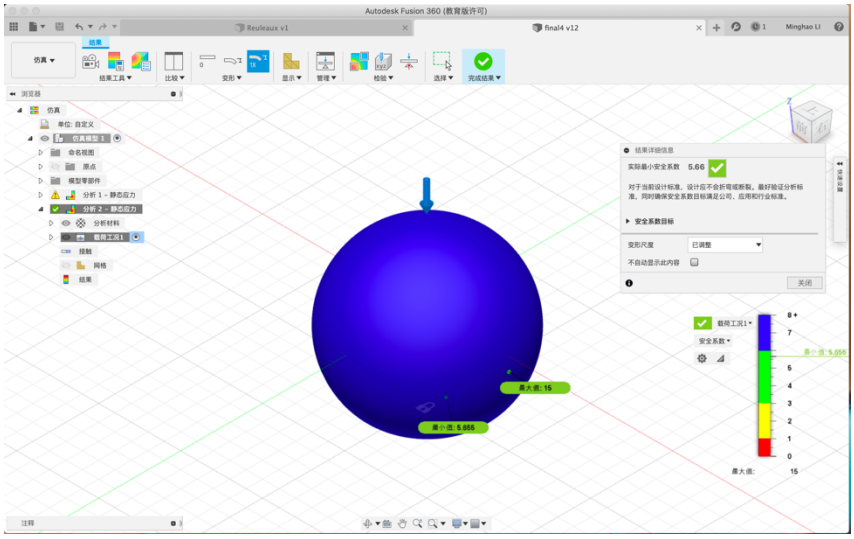
Problem 4

(1) Model: https://a360.co/3cQwQwN

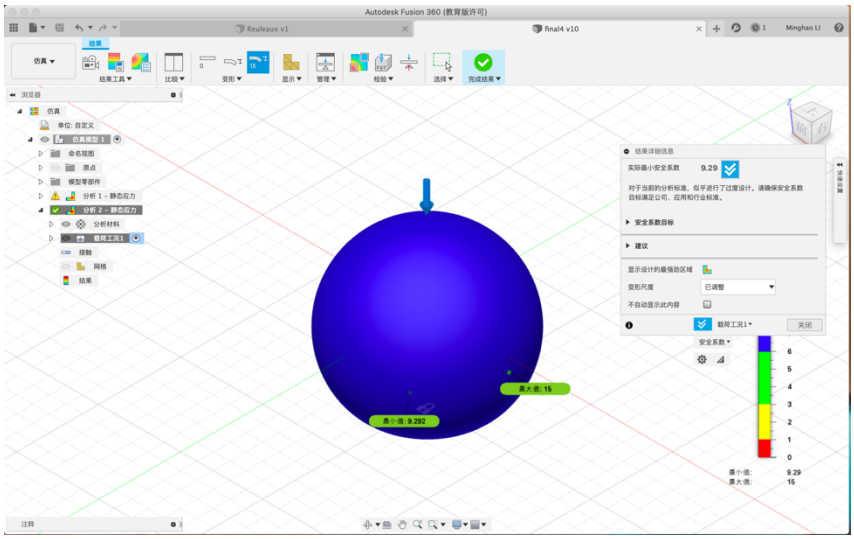


(2)

When the inner diameter is 4.6 mm, the minimal SF is 5.66. (SF > 5)



When the inner diameter is 4.7mm, the minimal SF is 3.8. (SF<5)



When the inner diameter is 4.5 mm, the minimal SF is 3.8. (SF<5)