第一讲: MatLab 基础

Matlab 编程与模型 / 算法实现

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Notes

Part I

MatLab 快速入门

Notes

简介

简史

MATLAB (矩阵实验室) 是 **MAT**rix **LAB**oratory 的缩写;

最初由美国的 Clever Moler 教授于 1980 年开发, 初衷是为了解决“线性代数”课程的矩阵运算问题;

是一款由 MathWorks 公司 (1984 年成立) 出品的数学软件.

特性

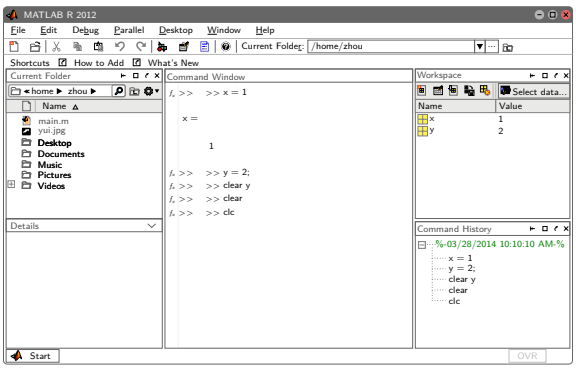
MATLAB 是一种用于算法开发, 数据可视化, 数据分析以及数值计算的高级技术计算语言和交互式环境.

MATLAB 可用来创建用户界面及调用其它语言编写的程序.

MATLAB 中包含众多的附加工具箱, 适合不同领域的应用.

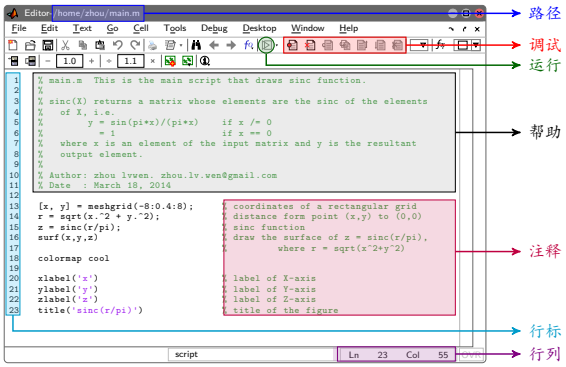
Notes

主窗介绍



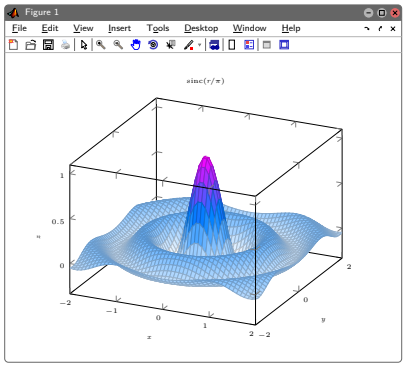
Notes

脚本窗口



Notes

图形窗口



Notes

获得帮助

帮助文档

如果你知道一个函数名, 想了解它的用法, 你可以用 'help' 命令得到它的帮助文档:

```
>> help functionname
```

如果你了解含某个关键词的函数, 你可以用 'lookfor' 命令得到相关的函数:

```
>> lookfor keyword
```

网络资源

Mathworks 文件交流中心: ▸ Mathworks

Github 代码托管网站: ▸ Github

Notes

实数, 复数, 行向量, 列向量, 矩阵的赋值

```
Command Window
>> x = 5
  x =
       5
>> x = [1 2 3]
  x =
       1    2    3
>> x = [1;2;3]
  x =
       1
       2
       3
>> clc
```


Notes

实数, 复数, 行向量, 列向量, 矩阵的赋值

```
Command Window
>> x = [1 2 3; 4 5 6; 7 8 9]
  x =
       1    2    3
       4    5    6
       7    8    9
>> y = [1 2 3
        4 5 6]
  y =
       1    2    3
       4    5    6
>>
```


Notes

向量的一般赋值方法

```
Command Window
>> x = [0:2]
  x =
    0.00    1.00    2.00
>> x = [0:2]'
  x =
    0.00
    1.00
    2.00
>> x = [0:0.5:2]
  x =
    0.00    0.50    1.00    1.50    2.00
>> x = linspace(0, 2, 5)
  x =
    0.00    0.50    1.00    1.50    2.00
>>
```


Notes

常用矩阵

```
Command Window
>> x = zeros(2,3)
  x =
    0.00    0.00    0.00
    0.00    0.00    0.00
>> y = ones(2)
  x =
    1.00    1.00
    1.00    1.00
>> x = eye(2)
  x =
    1.00    0.00
    0.00    1.00
>>
```


Notes

固定变量

```
Command Window
>> pi
  ans =
    3.1416
>> z = i
  z =
    0.00 + 1.00i
>> x = 1/0
  x =
     Inf
>> 0/0
  ans =
     NaN
>>
```


Notes

矩阵运算和数组运算

```
Command Window
>> A = [1 2 3; 4 5 6; 7 8 9];
>> B = [1 3 5; 6 9 0; 2 4 6];
>> C = A + B

  C =

       2    5    8
      10   14    6
       9   12   15

>> D = A - B

  D =

       0   -1   -2
      -2   -4    6
       5    4   03

>> clc
```


Notes

矩阵运算和数组运算

```
Command Window
>> A = [1 2 3; 4 5 6; 7 8 9];
>> B = [1 3 5; 6 9 0; 2 4 6];
>> E = A * B

  E =

      19   33   23
      46   81   56
      73  129   89

>> F = A.* B

  F =

       1    6   15
      24   45    0
      14   32   54

>> clc
```


Notes

矩阵运算和数组运算

```
Command Window
>> A = [1 2 3; 4 5 6; 7 8 9];
>> B = [1 3 5; 6 9 0; 2 4 6];
>> G = A / B

  G =

       0     0  0.50
   -3.00  0.00  3.50
   -6.00  0.00  6.50

>> H = A./ B

  H =

    1.00  0.67  0.60
    0.67  0.56   inf
    3.50  2.00  1.50

>> clc
```


Notes

矩阵运算和数组运算

```
Command Window
>> A = [1 2 3; 4 5 6; 7 8 9];
>> B = [1 3 5; 6 9 0; 2 4 6];
>> I = A ^ 2

  I =

      30   36   42
      66   81   96
     102  126  150

>> J = A.^ 2

  J =

       1    4    9
      16   25   36
      49   64   81

>> clc
```


Notes

数组和数组行列块操作: 取值

```
Command Window
>> A = [1 2 3; 4 5 6; 7 8 9];
>> x = A(1, 3)

  x =

       3

>> y = A(2, :)

  y =

       4    5    6

>> z = A(1:2, 1:3)

  z =

       1    2    3
       4    5    6

>>
```


Notes

数组和数组行列块操作: 赋值

```
Command Window
>> A = [1 2 3; 4 5 6; 7 8 9];
>> A(1, 3) = 0

  A =

       1    2    0
       4    5    6
       7    8    9

>> A(2, :) = [6 5 4]

  A =

       1    2    0
       6    5    4
       7    8    9

>> A(1:2, 1:2) = [-1 -2; -3 -4]

  A =

      -1   -2    0
      -3   -4    4
       7    8    9
```


Notes

数组操作函数: flipud, fliplr, rot90

```
Command Window
>> A = [1 2 3; 4 5 6; 7 8 9];
>> B = flipud(A)

  A =

       7    8    9
       4    5    6
       1    2    3

>> C = rot90(A)

  C =

       3    6    9
       2    5    8
       1    4    7

>>
```


Notes

数组操作函数: sum

```
Command Window
>> A = [1 2 3];
>> sum(A)

  ans =

       6

>> B = [1 2 3; 4 5 6; 7 8 9];
>> sum(B)

  ans =

      12   15   18

>> sum(B,2)

  ans =

       6
      15
      25

>>
```


Notes

数组操作函数: max, min

```
Command Window
>> A = [1 2 3];
>> max(A)
  ans =
       3
>> max(A,2)
  ans =
       2    2    3
>> B = [1 3 9; 4 8 6];
>> max(B)
  ans =
       4    8    9
>> max(B, [], 2)
  ans =
       9
       8
```


Notes

常用数学函数: sin, cos, tan, cot, asin, acos, atan, acot

```
Command Window
>> x = 0:pi/6:pi;
  x =
    0.00  0.52  1.05  1.57  2.09  2.62  3.14
>> y = sin(x)
  y =
    0.00  0.50  0.87  1.00  0.87  0.50  0.00
>> z = asin(y)
  z =
    0.00  0.52  1.05  1.57  2.09  2.62  3.14
>>
```


Notes

常用数学函数: abs, sqrt

```
Command Window
>> x = [-4 9 -16 25];
  x =
    -4    9  -16   25
>> y = abs(x)
  y =
     4    9   16   25
>> z = sqrt(y)
  z =
     1    3    4    5
>>
```


Notes

常用数学函数: ceil, fix, floor, round

```
Command Window
>> x = [-1.6 -0.2 1.2 0.6];
>> y = ceil(x)
  y =
    -1     0     2     1
>> z = floor(x)
  z =
    -2    -1     1     0
>> g = fix(x)
  g =
    -1     0     1     0
>> f = round(x)
  f =
    -2     0     1     1
>>
```


Notes

基本语句

基本语句

```
for .. end
if .. else .. end
while .. end
switch .. case .. end
```

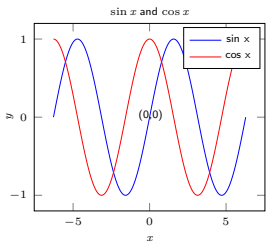
举例: 求 1-10 以内的奇数和

```
% sum of the odd numbers between 1 and 10
x = 0;
for i = 1:10
    if mod(i,2)
       x= x + i;
    end
end
```


Notes

简单作图

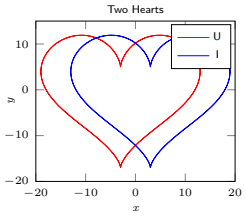
```
x = -2*pi:0.1:2*pi;
y1 = sin(x);
y2 = cos(x);
plot(x, y1, '-b');
hold on
plot(x, y2, '-r');
xlabel('x')
ylabel('y')
text(0,0, '(0,0)')
legend('sin x', 'cos x')
```



Notes

简单作图

```
t = 0:pi/180:4*pi;
x = 16*sin(t).^3;
y = 13*cos(t)-5*cos(2*t)...
    -2*cos(3*t)-cos(4*t);
plot(x-3,y,'-r', x+3,y,'-b');
xlabel('x');
ylabel('y');
axis([-20, 20, -20, 15]);
title('Two Heart')
legend('U', 'I')
```



Notes

简单作图

曲线图 plot: plot(x,y); plot(x,y,s), plot(x1,y1,s1,x2,y2,s2,...)

b	blue	.	point	-	solid
g	green	o	circle	:	dotted
r	red	x	x-mark	-.	dashdot
c	cyan	+	plus	--	dashed
m	magenta	*	star	(none)	no line
y	yellow	s	square		
k	black	d	diamond		
w	white	v	triangle (down)		
		^	triangle (up)		
		<	triangle (left)		
		>	triangle (right)		
		p	pentagram		
		h	hexagram		

Notes

简单控制语句

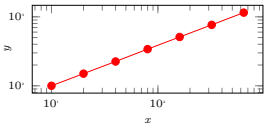
title(图形名称)
xlabel(x 轴说明); ylabel(y 轴说明)
text(x,y, 图形说明)
legend(图例 1, 图例 2, ...)
grid on / grid off / grid minor
axis([xmin xmax ymin ymax]), xlim([xmin, xmax])

Notes

其它坐标系

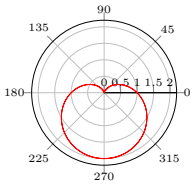
对数坐标: loglog, semilogx

```
x = 10*2.^[0:6];
y = [100 150 225 340 ...
     510 765 1150];
loglog(x,y,'.-r')
xlim([0.5e1,0.8e3])
ylim([0.8e2,1.4e3])
xlabel('x'); ylabel('y')
```



极坐标: polar

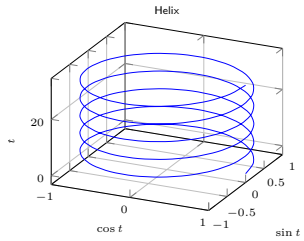
```
theta=0:pi/180:4*pi;
r=1-sin(theta);
polar(theta,r,'-r');
```



Notes

三维曲线图

```
t=0:pi/50:10*pi;
x = sin(t);
y = cos(t);
z = t;
plot3(x,y,z)
title('Helix')
xlabel('sin t')
ylabel('cos t')
zlabel('t')
grid on
```



Notes

三维曲面图: 补充函数 meshgrid

Command Window

```
>> [x, y] = meshgrid(1:3, 1:3)
  x =
       1     2     3
       1     2     3
       1     2     3
  y =
       1     1     1
       2     2     2
       3     3     3
>> rsq = (x-2).^2 + (x-2).^2
  rsq =
       2     1     2
       1     0     1
       2     1     2
>> r = sqrt(rsq)
  r =
    1.4142    1.0000    1.4142
    1.0000         0    1.0000
    1.4142    1.0000    1.4142
```

(1,1)	(2,1)	(3,1)
(1,2)	(2,2)	(3,2)
(1,3)	(2,3)	(3,3)

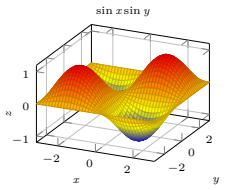
2	1	2
1	0	1
2	1	2

$\sqrt{2}$	1	$\sqrt{2}$
1	0	1
$\sqrt{2}$	1	$\sqrt{2}$

Notes

三维曲面图

```
1  [x,y] = meshgrid(-pi:0.1:pi);
2  z = sin(x).*cos(y);
3  mesh(x,y,z) % meshc(x,y,z)
4  surf(x,y,z) % surfc(x,y,z)
5  xlabel('x')
6  ylabel('y')
7  zlabel('z')
8  title('sin x sin y')
```



Notes

M 函数格式

M 函数格式

```
1  function [output 1, ..] = functionname(input1, ..)
2  % comment of this function
3
4  MatLab command 1;
5  MatLab command 2;
```

举例: 求矩形面积

```
1  function area = rectarea(L, W)
2  % rectarea  Area of a rectangle
3  %
4  %   rectarea(l, w) calculate the area of a rectangle
5  %   with a length of L and a width of W
6
7  area = L .* W
```

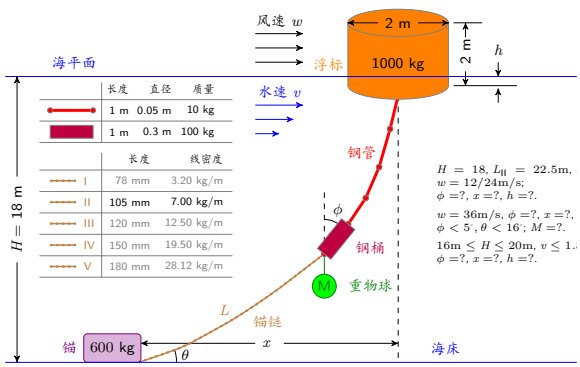

Notes

Part II

MatLab 编程实例: 系泊系统的设计

Notes

问题



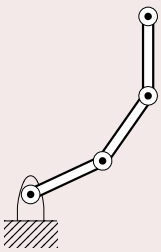
长度	直径	质量
1 m	0.05 m	10 kg
1 m	0.3 m	100 kg

	长度	线密度
I	78 mm	3.20 kg/m
II	105 mm	7.00 kg/m
III	120 mm	12.50 kg/m
IV	150 mm	19.50 kg/m
V	180 mm	28.12 kg/m

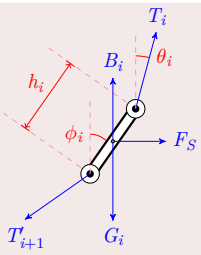
Notes

分析

简化为杆系结构



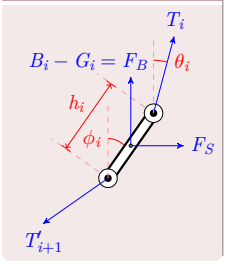
单杆的受力分析



Notes

单杆的平衡条件

单杆的受力分析



受力平衡：$F_x = 0,\ F_y = 0$

$$F_x = F_S + T_i \sin\theta_i - T_{i+1}\sin\theta_{i+1}$$
$$F_y = F_B + T_i \cos\theta_i - T_{i+1}\cos\theta_{i+1}$$

力矩平衡：$M_+ = M_-$

$$M_+ = \big(T_i \cos\theta_i + F_B/2\big) h_i \sin\phi_i$$
$$M_- = \big(T_i \sin\theta_i + F_S/2\big) h_i \cos\phi_i$$

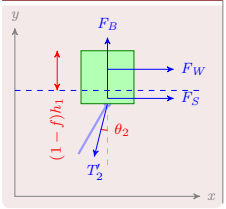
递推关系：$i > 1$

$$\mathbf{T}_{i+1} = \big(F_S + T_i\sin\theta_i, F_B + T_i\cos\theta_i\big),\ \tan\phi_i = \frac{T_i\sin\theta_i + F_S/2}{T_i\cos\theta_i + F_B/2}$$

Notes

浮标的平衡条件

受力分析图



受力平衡：$F_x = 0,\ F_y = 0$

$$F_x = -T_2\sin\theta_2 + F_W + F_D$$
$$F_y = -T_2\cos\theta_2 + F_B$$

计算力

$$F_B = \rho_{\text{sea}}\, f\pi (d/2)^2 h\, g - mg$$
$$F_W = C_W(1-f)hdv^2,\ F_S = C_S fhdv^2$$

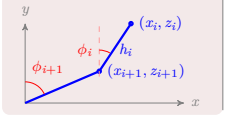
递推首项：$i = 1$

$$\mathbf{T}_2 = \big(F_W + F_S, F_B\big),\quad \tan\phi_1 = \frac{f/2F_S + \big[f + (1-f)/2\big]F_W}{f/2F_B}$$

Notes

各杆位置的确定

两杆的相对位置图



相对位置递推关系

$$x_{n+1} = 0,\ y_{n+1} = 0$$
$$x_i = x_{i+1} + h_i \sin\theta_i$$
$$y_i = y_{i+1} + h_i \cos\theta_i$$

二分法求解浮标吃水比例 f：$f_{\min} = 0,\ f_{\max} = 1$

$$f = \big(f_{\min} + f_{\max}\big) \Longrightarrow \begin{cases} y_1 - (1-f)h_1 > H & f \to f_{\max} \\ y_1 - (1-f)h_1 < H & f \to f_{\min} \end{cases}$$

Notes

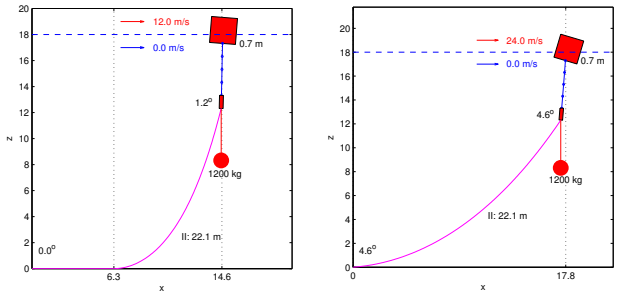
计算流程

初始设置 $f_{\min}=0$, $f_{\max}=1$

1. 由浮标吃水比例 $f=(f_{\min}+f_{\max})/2$ 计算浮标所受.
2. 由浮标浮力, 重力, 风力, 拉力四力平衡求得浮标对一号钢管 (第 2 节杆) 的拉力.
3. 迭代递推出出各节杆所受拉力和倾角 ϕ.
4. 根据 ϕ 将各杆长度投影到竖直方向, 求得浮标吃水线距离海床的高度 Z_w.
5. 如果 $Z_w>18$, 则 $f_{\max}=f$; 否则 $f_{\min}=f$.
6. 如果 $f_{\max}-f_{\min}<E$, 输出结果; 否则回到 1.

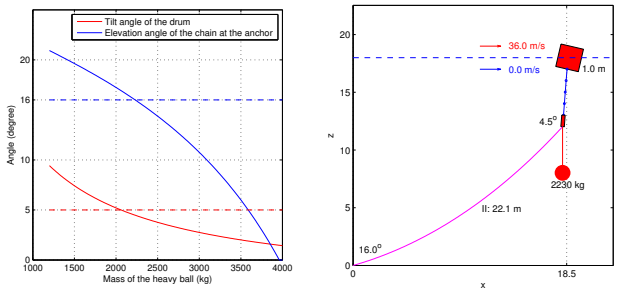
Notes

结果: 问题一



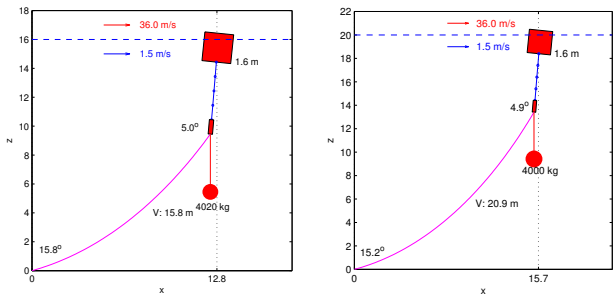
Notes

结果: 问题二



Notes

结果: 问题三



Notes

主函数

moor

```
01 function [tilt,elev,xbuoy,f] = moor(Lc,chain,vw,vs,M,depth)
02 g = 9.81; rho = 1.025e3; rhoFe = 7.9e3; cdwin = 0.625;
03 [lc, mc, dc] = chainpara(chain); nc = round(Lc/lc);
04 m = [1000,   10*ones(1,4), 100, mc*ones(1,nc)];
05 h = [   2,      ones(1,4),   1, lc*ones(1,nc)];
06 d = [   2, 5e-2*ones(1,4), 0.3, dc*ones(1,nc)];
07 Fb = pi*(d/2).^2.*h*rho*g - m*g;
08 phi = zeros(1,length(h)); fmin = 0; fmax = 1;
09 while fmax-fmin>1e-10
10     f = (fmax+fmin)/2;
11     Fb(1) = rho * f*pi*(d(1)/2).^2.*h(1) * g - m(1)*g;
12     Fw = cdwin * (1-f)*h(1).*d(1) * vw.^2;
13     Fs = waterload(vs, h, d, phi, depth, f);
14     phi = solvequileq(Fb, Fw, Fs, M, f);
15     x = h.*sin(phi); z = h.*cos(phi);
16     if sum(z(2:end))+h(1)*f>depth; fmax=f; else; fmin=f; end
17 end
18 x = cumsum([0 fliplr(x)]);  z = cumsum([0 fliplr(z)]);
19 tilt = phi(6)*180/pi;       elev = 90- phi(end)*180/pi;
20 xsbed = max(x(z<1e-10));    xbuoy = x(end-1);
```

Notes

锚链参数和近海风荷载

chainpara

```
01 function [lc, mc, dc] = chainpara(typeid)
02 rhoFe = 7.9e3;                          % kg/m^3
03 rho= [3.2 7.0 12.5 19.5 28.12];         % kg/m
04 lc = [ 78 105  120  150   180]*1e-3; % m
05 mc = rho.*lc;                           % kg
06 lc = lc(typeid); mc = mc(typeid);
07 dc = 2*sqrt(rho(typeid)/rhoFe/pi);
```

waterload

```
08 function Fs = waterload(vs, h, d, phi, depth, f)
09 cd = 374;
10 z = h.*cos(phi);
11 zi = fliplr(cumsum(fliplr(z))) - z/2;
12 zi(1) = depth - f*h(1)/2;
13 vsi = vs./sqrt(depth)*sqrt(zi);
14 Fs = cd * h.*d.*cos(phi) .* vsi.^2;
15 Fs(1) = Fs(1)*f;
```

Notes

解平衡方程求倾斜角度

solvequileq

```
01 function phi = solvequileq(Fb, Fw, Fs, M, f)
02 g = 9.81; N = length(Fb);
03 rho = 1.025e3; rhoFe = 7.9e3
04 [theta, phi, Ft] = deal(zeros(1,N));
05 for i = 1:N-1
06     fx = Ft(i)*sin(theta(i)) + Fs(i);
07     if i==1; fx = fx + Fw; end
08     fz = Fb(i) + Ft(i)*cos(theta(i));
09     if i==6; fz = fz -M*g + rho*(M/rhoFe)*g; end
10     Ft(i+1) = sqrt(fx^2+fz^2);
11     theta(i+1) = acos(fz/Ft(i+1));
12     if theta(i+1)>pi/2; theta(i+1) = pi/2; end
13 end
14 phi =atan2( Ft.*sin(theta)+Fs/2, Ft.*cos(theta)+Fb/2);
15 phi(phi>pi/2) = pi/2;
16 phi(1) = atan2( Fs(1)*f/2+Fw(1)*(f+(1-f)/2), Fb(1)*f/2 );
```


Notes

主程序

问题一

```
01 Lc = 22.05;chain = 2; M = 1200; depth = 18; vs = 0;
02 [tilt,elev,xbuoy,f] = moor(Lc, chain, 12, vs, M, depth);
03 [tilt,elev,xbuoy,f] = moor(Lc, chain, 24, vs, M, depth);
```

问题二

```
04 Mi = 1200:10:4000; tilti = []; elevi = [];
05 for mi = Mi
06     [tilt,elev,xbuoy,f] = moor(Lc,chain,36,0,mi,depth);
07     tilti = [tilti,tilt]; elevi = [elevi,elev];
08 end
09 plot(Mi, tilti,'r', Mi, elevi, 'b');
```

问题三：一个符合条件的算例

```
10 Lc = 20.88;chain = 5; M = 4000; depth = 20; vw = 36;vs = 1.5;
11 [tilt,elev,xbuoy,f] = moor(Lc,chain,vw,vs,M,depth);
```


Notes

Thank You!!!

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