MATLAB FINAL by Cole Bardin Section 61

Part A

Question 1

```
clc, clear, close all
a1=[6,-6,0;3,-3,0;1,-1,0]
```

```
a1 = 3×3
     6    -6     0
     3    -3     0
     1    -1     0
```

```
a2=[-2,6,9;-2,5,6;0,0,1]
```

```
a2 = 3×3
    -2     6     9
    -2     5     6
     0     0     1
```

```
a3=[-2,6,14;-2,5,8;0,0,3]
```

```
a3 = 3×3
    -2     6    14
    -2     5     8
     0     0     3
```

```
a4=[-4,10,15;-3,7,8;0,0,3]
```

```
a4 = 3×3
    -4    10    15
    -3     7     8
     0     0     3
```

```
eig(a1)
```

```
ans = 3×1
     0
     0
     3
```

```
eig(a2)
```

```
ans = 3×1
    1.0000
    2.0000
    1.0000
```

```
eig(a3)
```

```
ans = 3×1
    1.0000
    2.0000
    3.0000
```

```
eig(a4)
```

```
ans = 3×1
    1.0000
    2.0000
    3.0000
```

Question 2

```
clc, clear, close all
A=[-24,16,-16;-40,28,-28;-4,4,-4]
```

```
A = 3×3
   -24    16   -16
   -40    28   -28
    -4     4    -4
```

```
eig(A)
```

```
ans = 3×1 complex
10^-4 ×
   0.3608 + 0.6249i
   0.3608 - 0.6249i
  -0.7216 + 0.0000i
```

```
rref([A,[0;0;0]])
```

```
ans = 3×4
     1     0     0     0
     0     1    -1     0
     0     0     0     0
```

```
v1=[0;1;1]
```

```
v1 = 3×1
     0
     1
     1
```

```
rref([A,v1])
```

```
ans = 3×4
    1.0000         0         0    0.5000
         0    1.0000   -1.0000    0.7500
         0         0         0         0
```

Question 3

```
clc, clear, close all
syms y(t);
y0=0;yp0=1;
dy=diff(y,t); d2y=diff(y,t,t);
DE = d2y+y
```

```
DE(t) =
```

$$\frac{\partial^2}{\partial t^2}\, y(t) + y(t)$$

```
Fa = t
```

Fa = t

```
Fb = -2*sin(t)
```

Fb = $-2\sin(t)$

```
Fc = 2*cos(t)
```

Fc = $2\cos(t)$

```
Fd = sin(t)
```

Fd = $\sin(t)$

```
simplify(dsolve(DE==Fa,y(0)==y0,dy(0)==yp0))
```

ans = t

```
simplify(dsolve(DE==Fb,y(0)==y0,dy(0)==yp0))
```

ans = $t\cos(t)$

```
simplify(dsolve(DE==Fc,y(0)==y0,dy(0)==yp0))
```

ans = $\sin(t)\ (t+1)$

```
simplify(dsolve(DE==Fd,y(0)==y0,dy(0)==yp0))
```

ans =

$$\frac{3\sin(t)}{2} - \frac{t\cos(t)}{2}$$

Question 4

```
clc, clear, close all
syms s;
Fs = (3125*s)/( (s-2)*(s-2)*(s-2)*(s+3)*(s+3)*(s+3) )
```

Fs =

$$\frac{3125\,s}{(s-2)^3\,(s+3)^3}$$

```
PF = partfrac(Fs)
```

PF =

$$\frac{3}{s+3} - \frac{5}{(s-2)^2} - \frac{3}{s-2} + \frac{50}{(s-2)^3} + \frac{20}{(s+3)^2} + \frac{75}{(s+3)^3}$$

Question 5

```
clc, clear, close all
syms y(x);
y0=0;dy0=0;
dy=diff(y,x); d2y=diff(y,x,x);
DEa = d2y + 3*dy + 2*y == exp(-1*x)
```

DEa(x) =

$$\frac{\partial^2}{\partial x^2}\, y(x) + 3\,\frac{\partial}{\partial x}\, y(x) + 2\, y(x) = \mathrm{e}^{-x}$$

```
DEb = d2y + 4*dy + 3*y == 4*x*exp(-1*x)
```

DEb(x) =

$$\frac{\partial^2}{\partial x^2}\, y(x) + 4\,\frac{\partial}{\partial x}\, y(x) + 3\, y(x) = 4\, x\, \mathrm{e}^{-x}$$

```
DEc = d2y + dy == x*exp(-1*x)
```

DEc(x) =

$$\frac{\partial^2}{\partial x^2}\, y(x) + \frac{\partial}{\partial x}\, y(x) = x\, \mathrm{e}^{-x}$$

```
DEd = d2y + 3*dy + 2*y == 2*(1+x)*exp(-1*x)
```

DEd(x) =

$$\frac{\partial^2}{\partial x^2}\, y(x) + 3\,\frac{\partial}{\partial x}\, y(x) + 2\, y(x) = \mathrm{e}^{-x}\,(2\,x + 2)$$

```
simplify(dsolve(DEa,y(0)==y0,dy(0)==dy0))
```

ans = $\mathrm{e}^{-2\,x}\,(x\,\mathrm{e}^{x} - \mathrm{e}^{x} + 1)$

```
simplify(dsolve(DEb,y(0)==y0,dy(0)==dy0))
```

ans =

$$x^2\,\mathrm{e}^{-x} - \frac{\mathrm{e}^{-3\,x}}{2} - \frac{\mathrm{e}^{-x}\,(2\,x - 1)}{2}$$

```
simplify(dsolve(DEc,y(0)==y0,dy(0)==dy0))
```

ans =

$$-\frac{\mathrm{e}^{-x}\,(2\,x - 2\,\mathrm{e}^{x} + x^2 + 2)}{2}$$

```
simplify(dsolve(DEd,y(0)==y0,dy(0)==dy0))
```

ans = $x^2\,\mathrm{e}^{-x}$

Part B

Questions 3-5

```
clc, clear, close all
syms x(t) y(t);
xm=[x;y];
x0=[-0.28;0.00];
time = 00;001;8;
```

Part C

Points 1-10

```
clc, clear, close all
syms Y t s;
y0=-60;dy0=0;
f=12+12*sin(t)
```

f = $12\sin(t)+12$

```
% Point 1
F=laplace(f)
```

F =

$$\frac{12}{s^2+1}+\frac{12}{s}$$

```
d2Y = s*s*Y-s*y0-dy0
```

d2Y = $Y s^2+60 s$

```
dY = (1/6)*(s*Y - y0)
```

dY =

$$\frac{Y s}{6}+10$$

```
LTofDE = d2Y + dY + Y == F
```

LTofDE =

$$Y+60 s+\frac{Y s}{6}+Y s^2+10=\frac{12}{s^2+1}+\frac{12}{s}$$

```
Sol = solve(LTofDE, Y)
```

Sol =

$$-\frac{60 s^2-12}{s^3+s}$$

```
Y = matlabFunction(Sol);
```

```
% Point 2
Y(s);
% Point 3
PF = partfrac(Y(s))
```

```
PF =
```

$$\frac{12}{s} - \frac{72\,s}{s^2+1}$$

```
% Point 4
limit(Y(s),s,inf)
```

```
ans = 0
```

```
% Point 5
y=ilaplace(Y(s))
```

```
y = 12 - 72*cos(t)
```

```
% Point 6
dy = matlabFunction(simplify(diff(y,t)))
```

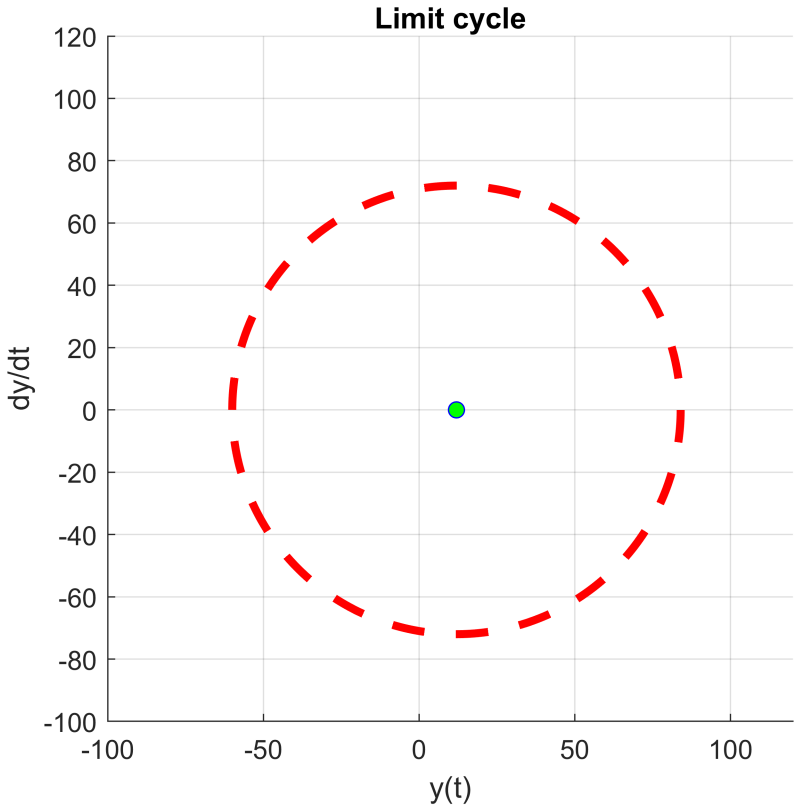
```
dy = function_handle with value:
    @(t)sin(t).*7.2e+1
```

```
y=matlabFunction(y)
```

```
y = function_handle with value:
    @(t)cos(t).*-7.2e+1+1.2e+1
```

```
% Points 7-8
time=[0:0.01:2*pi];

grid on
hold on
limit = plot(y(time), dy(time), 'r--', "LineWidth",3);
center = plot(12,0, 'bo', "MarkerFaceColor",'g');
axis equal
axis([-100, 120, -100, 120])
xlabel("y(t)");
ylabel("dy/dt");
title("Limit cycle");
```



Points 9-10

```
clc, clear, close all
syms x(t) y(t);
xm=[x;y];
x0=[-0.28;0.00];
time = [0,8];
sol = ode45(@diffeq65,time,x0)
```

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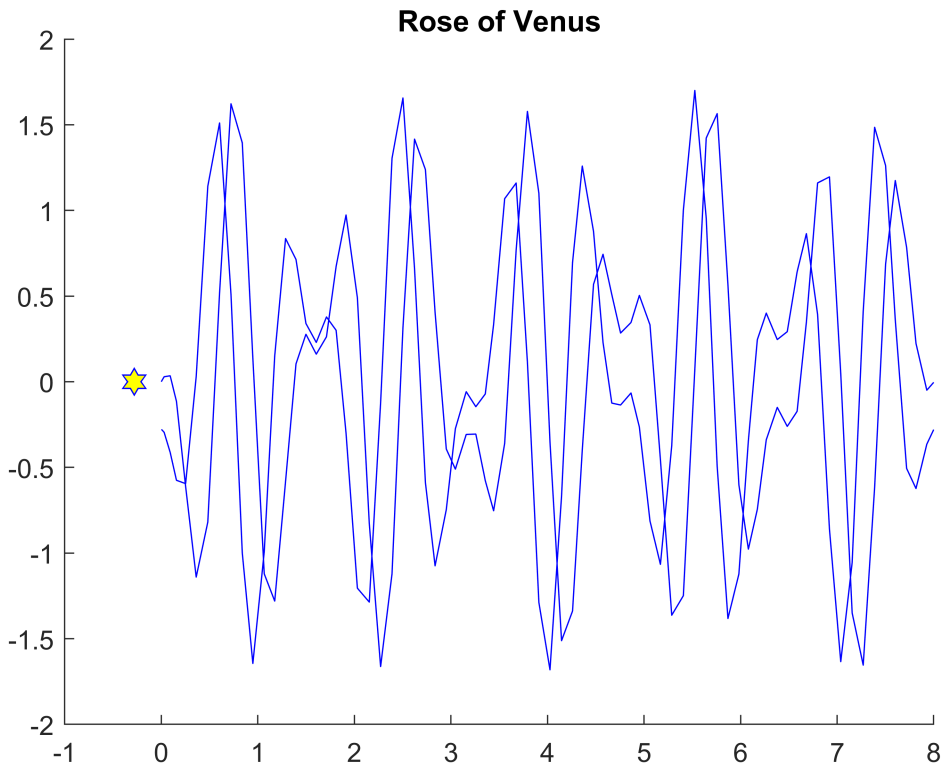
sol = struct with fields:
     solver: 'ode45'
    extdata: [1×1 struct]
          x: [1×79 double]
          y: [2×79 double]
      stats: [1×1 struct]
      idata: [1×1 struct]
```

```
hold on
plot(sol.x, sol.y, 'b')
plot(-0.28, 0, "bh", "MarkerSize",10,"MarkerFaceColor",'y');
title("Rose of Venus")
```



Part C

Points 1-10

```
clc, clear, close all
syms Y t s;
y0=-60;dy0=0;
f=12+12*sin(t)
```

f = $12\sin(t)+12$

```
% Point 1
F=laplace(f)
```

F =

$$\frac{12}{s^2+1}+\frac{12}{s}$$

```
d2Y = s*s*Y-s*y0-dy0
```

d2Y = $Y s^2+60 s$

```
dY = (1/6)*(s*Y - y0)
```

dY =

$$\frac{Y s}{6}+10$$

```
LTofDE = d2Y + dY + Y == F
```

LTofDE =

$$Y+60 s+\frac{Y s}{6}+Y s^2+10=\frac{12}{s^2+1}+\frac{12}{s}$$

```
Sol = solve(LTofDE, Y)
```

Sol =

$$-\frac{60 s^2-12}{s^3+s}$$

```
Y = matlabFunction(Sol);
% Point 2
Y(s);
% Point 3
PF = partfrac(Y(s))
```

PF =

$$\frac{12}{s}-\frac{72 s}{s^2+1}$$

```
% Point 4
limit(Y(s),s,inf)
```

ans = 0

```
% Point 5
y=ilaplace(Y(s))
```

y = $12 - 72\cos(t)$

```
% Point 6
dy = matlabFunction(simplify(diff(y,t)))
```

```
dy = function_handle with value:
    @(t)sin(t).*7.2e+1
```

```
y=matlabFunction(y)
```

```
y = function_handle with value:
    @(t)cos(t).*-7.2e+1+1.2e+1
```

```
% Points 7-8
time=[0:0.05:2*pi];
grid on
hold on
limit = plot(y(time), dy(time), 'r.', "LineWidth",3);
center = plot(12,0, 'bo', "MarkerFaceColor",'g', "MarkerSize",10);
axis equal
axis([-100, 120, -100, 120])
xlabel("y(t)");
ylabel("dy/dt");
title("Limit Cycle")

% Points 9-10
clear
grid off
syms Y t s;
y0=0;dy0=0;
f=12+12*sin(t)
```

f = $12\sin(t) + 12$

```
F=laplace(f)
```

F =

$$\frac{12}{s^2+1} + \frac{12}{s}$$

```
d2Y = s*s*Y-s*y0-dy0
```

d2Y = $Y\,s^2$

```
dY = (1/6)*(s*Y - y0)
```

dY =

$$\frac{Y\,s}{6}$$

```
LTofDE = d2Y + dY + Y == F
```

LTofDE =

$$Y s^2 + \frac{Y s}{6} + Y = \frac{12}{s^2 + 1} + \frac{12}{s}$$

```
Sol = solve(LTofDE, Y)
```

Sol =

$$\frac{\frac{12}{s^2 + 1} + \frac{12}{s}}{s^2 + \frac{s}{6} + 1}$$

```
Y = matlabFunction(Sol);
Y(s);
PF = partfrac(Y(s))
```

PF =

$$\frac{12}{s} - \frac{72 s}{s^2 + 1} + \frac{360 s + 60}{6 s^2 + s + 6}$$

```
limit(Y(s),s,inf)
```

ans = 0

```
y=ilaplace(Y(s))
```

y =

$$60\, e^{-\frac{t}{12}} \left(\cos\left(\frac{\sqrt{143}\, t}{12} \right) + \frac{\sqrt{143}\, \sin\left(\frac{\sqrt{143}\, t}{12} \right)}{143} \right) - 72 \cos(t) + 12$$

```
dy = matlabFunction(simplify(diff(y,t)))
```

dy = *function_handle with value:*

```
@(t)sin(t).*7.2e+1-sqrt(1.43e+2).*exp(t.*(-1.0./1.2e+1)).*sin((sqrt(1.43e+2).*t)./1.2e+1).*(7.2e+2./1.43e+2)
```

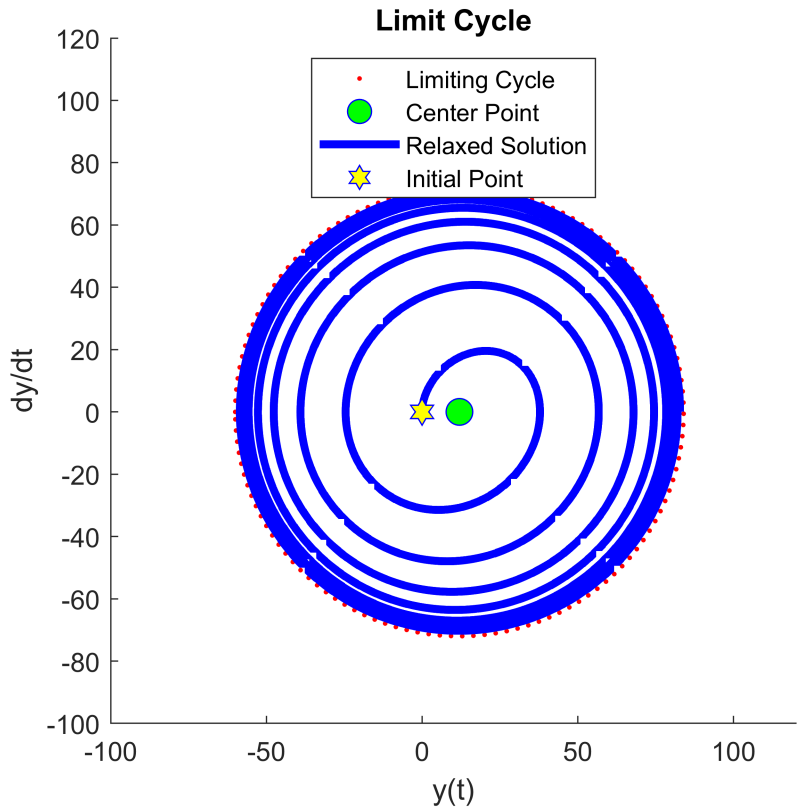
```
y=matlabFunction(y)
```

y = *function_handle with value:*

```
@(t)cos(t).*-7.2e+1+exp(t.*(-1.0./1.2e+1)).*(cos((sqrt(1.43e+2).*t)./1.2e+1)+(sqrt(1.43e+2).*sin((sqrt(1.43e+2)
```

```
time=[0:0.01:15*pi];
rel = plot(y(time), dy(time),'b', "LineWidth",3);
ip = plot(0,0, 'bh', "MarkerFaceColor",'y', "MarkerSize",10);

legend(["Limiting Cycle","Center Point","Relaxed Solution","Initial Point"],"Location","north"
```



Part D

```
% Points 1-5
clc, clear, close all
syms s t;
Re = 1.00; Rv = 0.72;       % in astronomical units
we = 2*pi; wv = 2*pi *13/8; % angular frequencies for Earth and Venus
c = (wv - we) * Rv % 2.8274
```

```
c = 2.8274
```

```
A=[0,-2*pi;2*pi,0];
f=c*[-1*sin(wv*t);cos(wv*t)];
x0=[-0.28;0.00];

% Point 1
R = inv(s*eye(2)-A)
```

```
R =
```

$$\begin{pmatrix} \frac{s}{s^2+4\pi^2} & -\frac{2\pi}{s^2+4\pi^2} \\ \frac{2\pi}{s^2+4\pi^2} & \frac{s}{s^2+4\pi^2} \end{pmatrix}$$

```
% Point 2
F = laplace(f)
```

F =

$$\begin{pmatrix} -\frac{117\,\pi^2}{40\left(s^2+\frac{169\,\pi^2}{16}\right)} \\ \frac{9\,\pi\,s}{10\left(s^2+\frac{169\,\pi^2}{16}\right)} \end{pmatrix}$$

```
% Point 3
xzi = R*x0
```

xzi =

$$\begin{pmatrix} -\frac{7\,s}{25\,(s^2+4\,\pi^2)} \\ -\frac{14\,\pi}{25\,(s^2+4\,\pi^2)} \end{pmatrix}$$

```
% Point 4
xzs = simplify(R*F)
```

xzs =

$$\begin{pmatrix} -\frac{189\,s\,\pi^2}{40\,(s^2+4\,\pi^2)\left(s^2+\frac{169\,\pi^2}{16}\right)} \\ -\frac{36\,\pi\,(13\,\pi^2-2\,s^2)}{5\,(16\,s^4+233\,\pi^2\,s^2+676\,\pi^4)} \end{pmatrix}$$

```
% Point 5
X=xzi+xzs
```

X =

$$\begin{pmatrix} -\frac{7\,s}{25\,\sigma_1}-\frac{189\,s\,\pi^2}{40\,\sigma_1\left(s^2+\frac{169\,\pi^2}{16}\right)} \\ -\frac{14\,\pi}{25\,\sigma_1}-\frac{36\,\pi\,(13\,\pi^2-2\,s^2)}{5\,(16\,s^4+233\,\pi^2\,s^2+676\,\pi^4)} \end{pmatrix}$$

where

$$\sigma_1 = s^2+4\,\pi^2$$

```
x=matlabFunction(ilaplace(X))
```

x = *function_handle with value:*

```
    @(t)[-cos(t.*pi.*2.0)+cos(t.*pi.*(1.3e+1./4.0)).*(1.8e+1./2.5e+1);-sin(t.*pi.*2.0)+sin(t.*pi.*(1.3e+1./4.0)).*(1
```

```
x(4)
```

```
ans = 2×1
   -1.7200
```

```
-0.0000
```