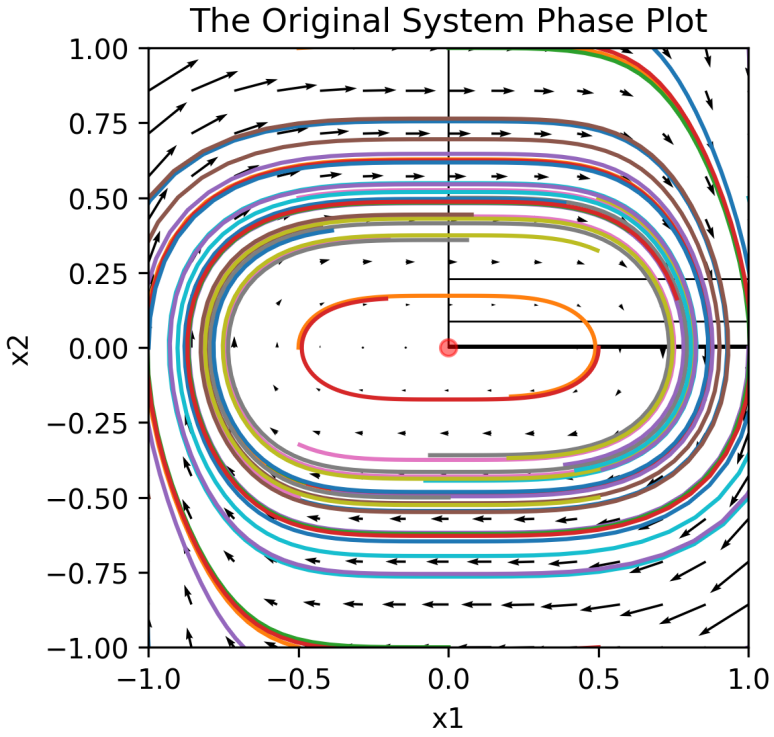
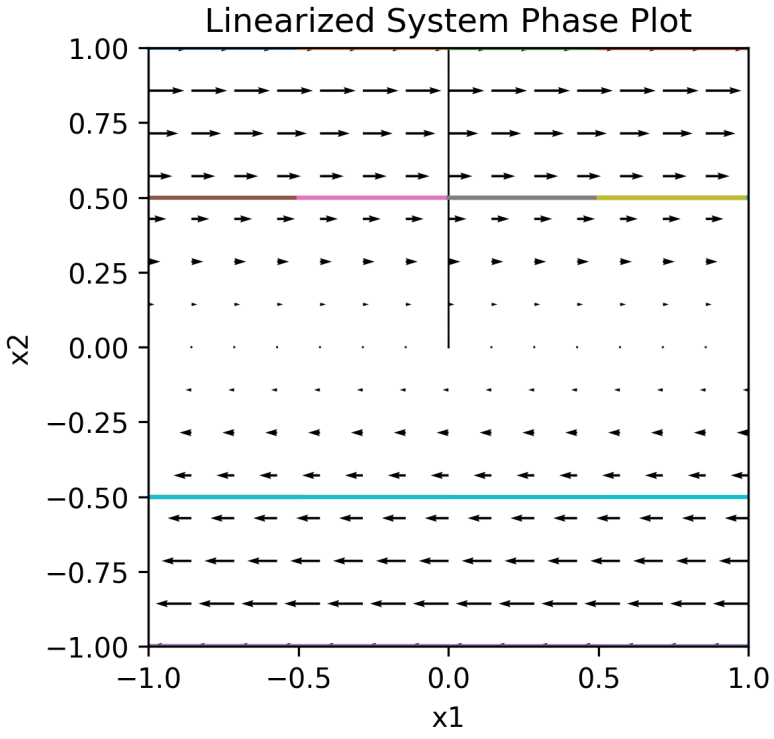
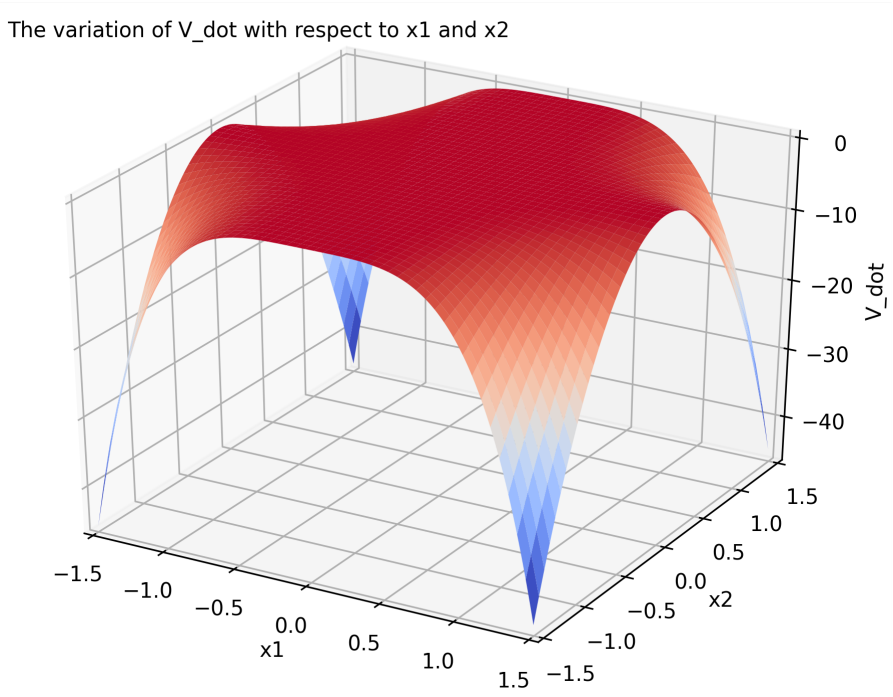
Ex 5. Plot and Code

(c)





(d)



Code for Ex.5 (c)

```
! pip install control  # need control library

import numpy as np
import matplotlib.pyplot as plt
from control.phaseplot import phase_plot

# Clear out any figures that are present
plt.close('all')

# Define the ODEs
def NLTI_ode(x, t):
    return [x[1] - x[0]*x[1]**2, -x[0]**3]

def LTI_ode(x, t):
    return [x[1], 0]

x = np.linspace(-1, 1, 5)
y = np.linspace(-1, 1, 5)
xv, yv = np.meshgrid(x, y)
X0 = np.hstack((xv.reshape(-1,1), yv.reshape(-1,1)))

# the original system
plt.figure(1, dpi = 300)
plt.gca().set_aspect('equal', adjustable='box')
plt.axis([-1, 1, -1, 1])
plt.title('The Original System Phase Plot')

phase_plot(
    NLTI_ode,
    X0 = X0,
    X = (-1, 1, 15),
    Y = (-1, 1, 15),
    T = 10
)
```

```
plt.scatter(x = 0,
            y = 0,
            c='r',
            alpha=0.5)
plt.show()

# linearized system
plt.figure(2, dpi = 300)
plt.gca().set_aspect('equal', adjustable='box')
plt.axis([-1, 1, -1, 1])
plt.title('Linearized System Phase Plot')

phase_plot(
    LTI_ode,
    X0 = X0,
    X = (-1, 1, 15),
    Y = (-1, 1, 15),
    T = 10
)
plt.show()
```

Code for Ex.5 (d)

```
import numpy as np
import matplotlib.pyplot as plt
from matplotlib import cm
import mpl_toolkits.mplot3d

fig = plt.figure(figsize=(8, 6),dpi = 300)
ax = fig.add_subplot(111, projection='3d')
# ax = plt.subplots(subplot_kw={"projection": "3d"})

x1 = np.arange(-1.5, 1.5, 0.005)
x2 = np.arange(-1.5, 1.5, 0.005)
x1, x2 = np.meshgrid(x1, x2)
V_dot = -4*np.power(x1, 4)*np.power(x2,2)

ax.text2D(0.05, 0.95, "The variation of V_dot with respect to x1 and x2",
transform=ax.transAxes)
surf = ax.plot_surface(x1, x2, V_dot, cmap=cm.coolwarm)
ax.set_xlim(-1.5, 1.5)
ax.set_ylim(-1.5, 1.5)
ax.set_xlabel('x1')
ax.set_ylabel('x2')
ax.set_zlabel('V_dot')
plt.show()
```