a)

b)

= J(θ) =

Because we do not need to give the part of the Jacobian that deals with orientations, so

J(θ) = =

where, is the position of joint , and is the unit axis of joint .

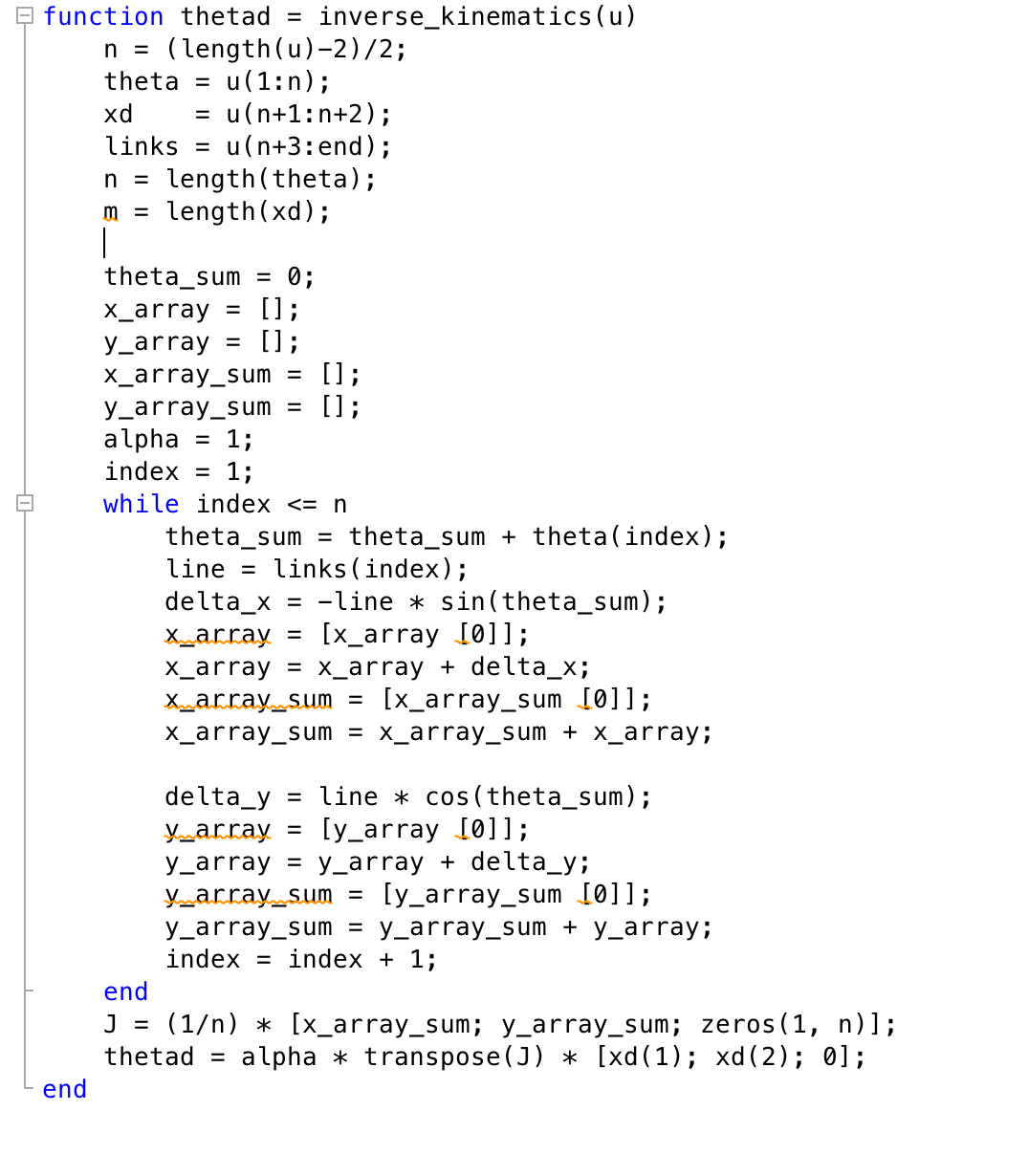
c)

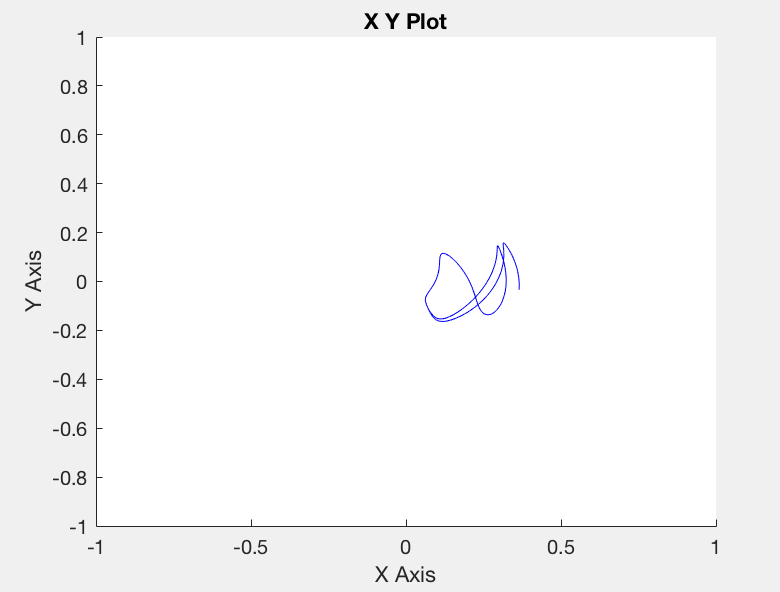
d)

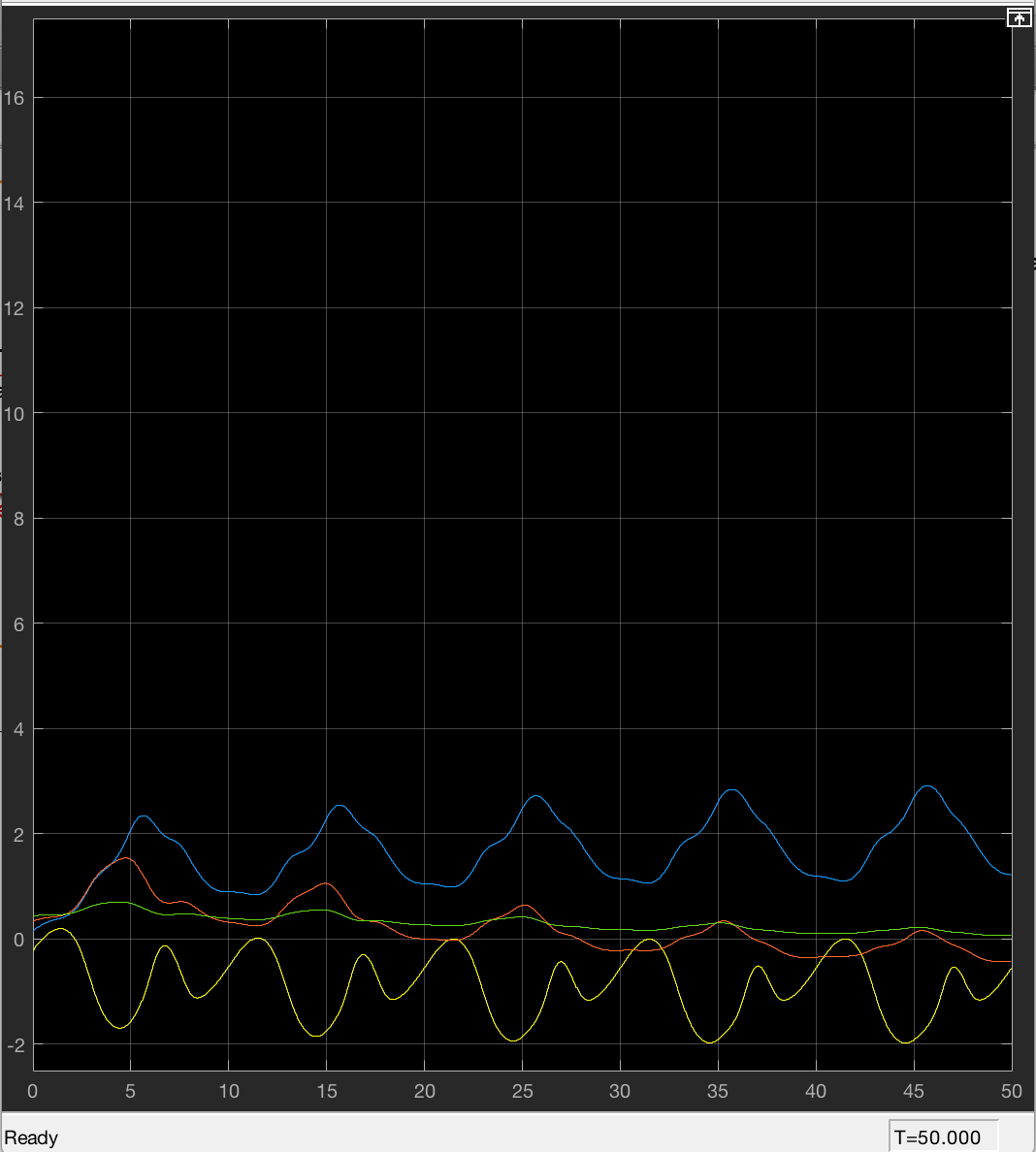
e)

f)

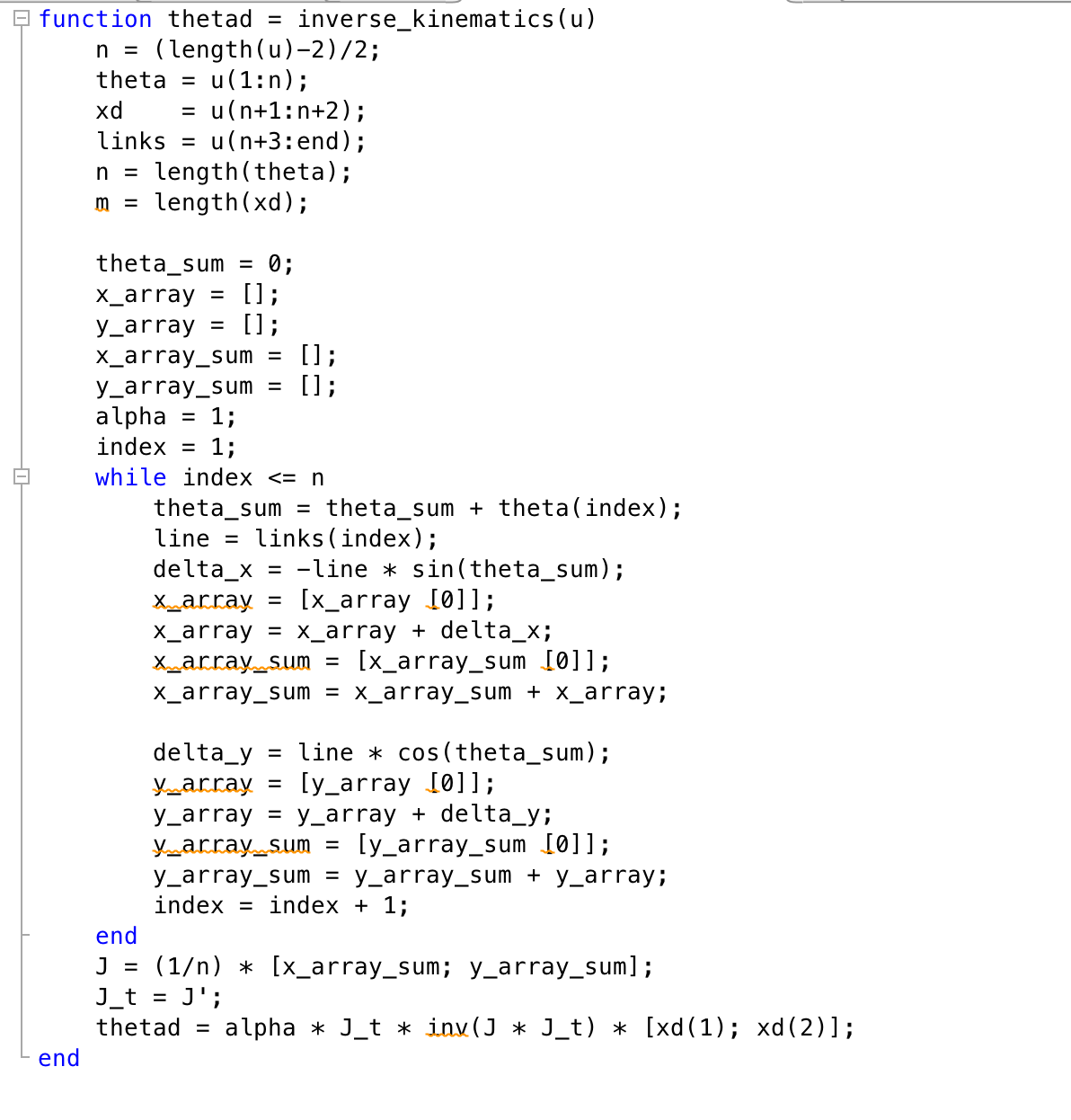
(g)

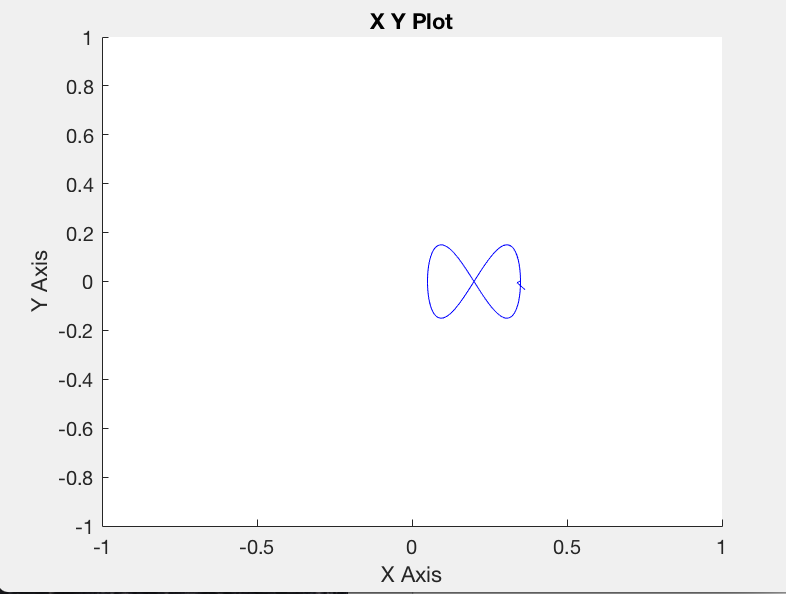


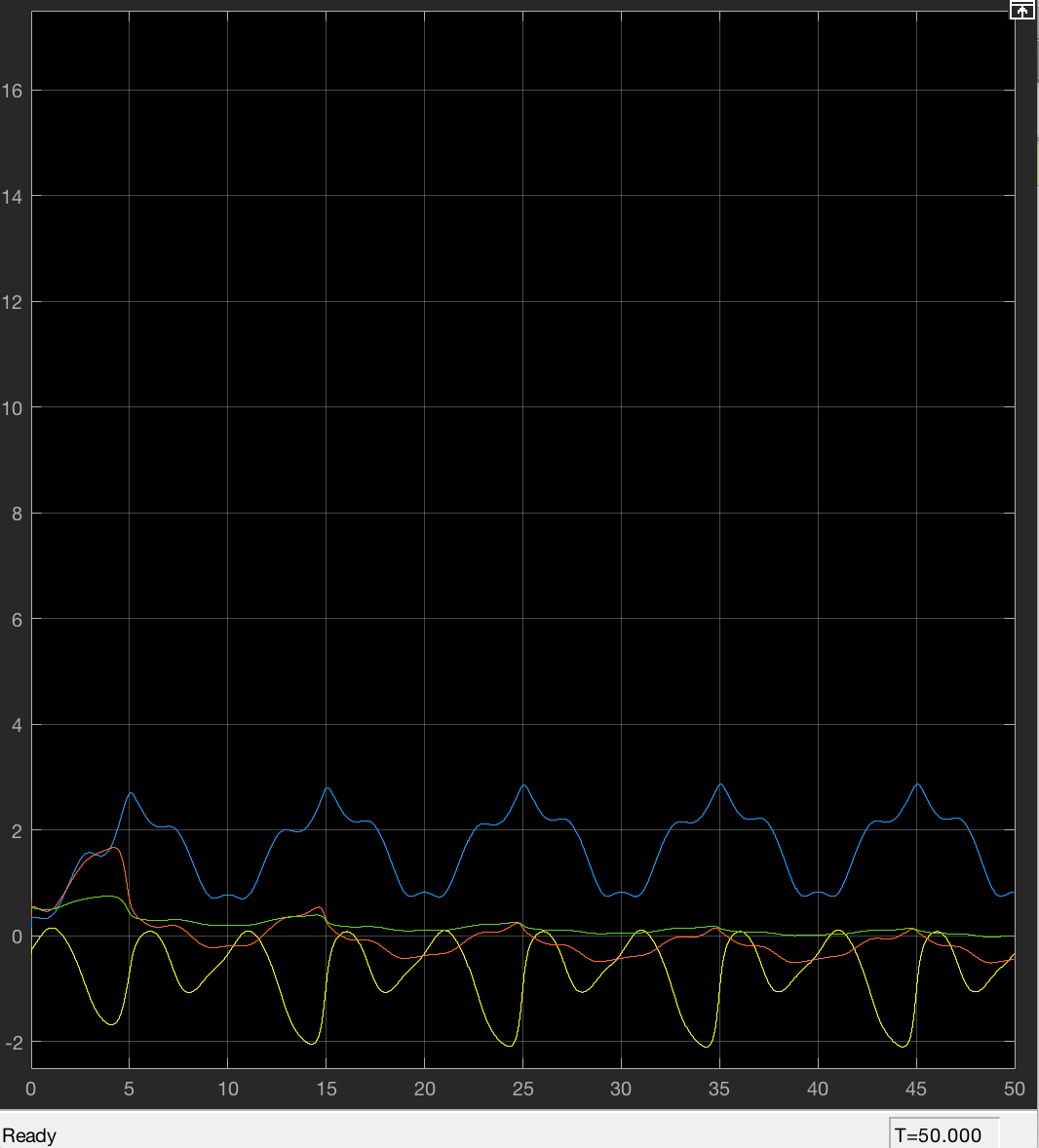




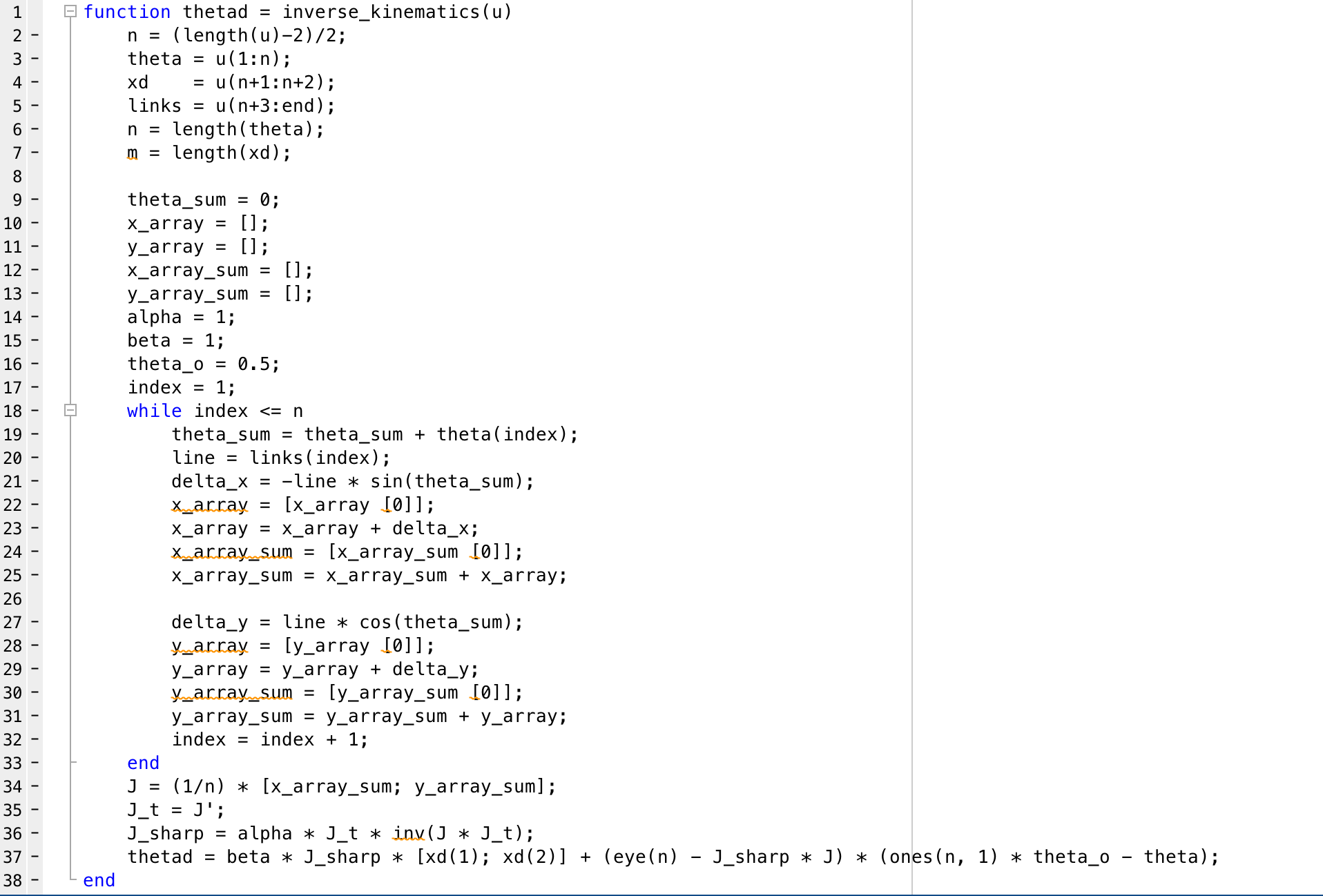
h)

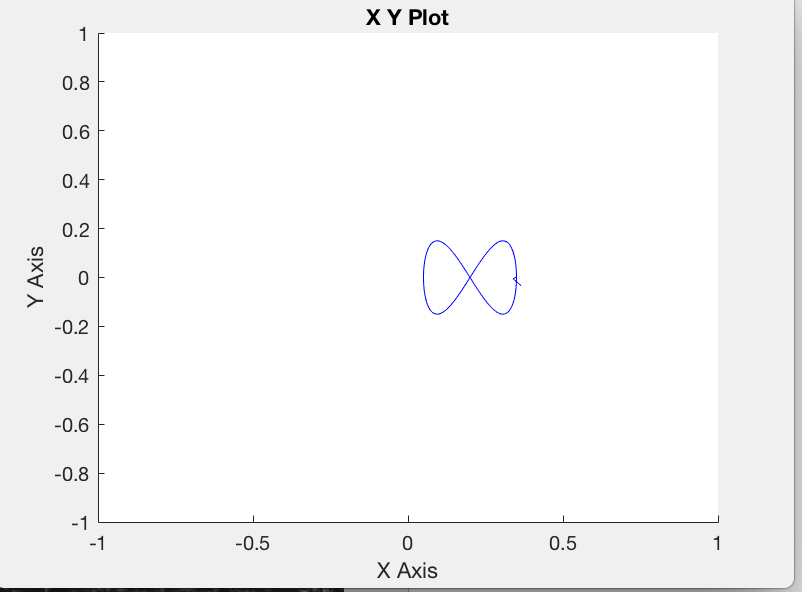


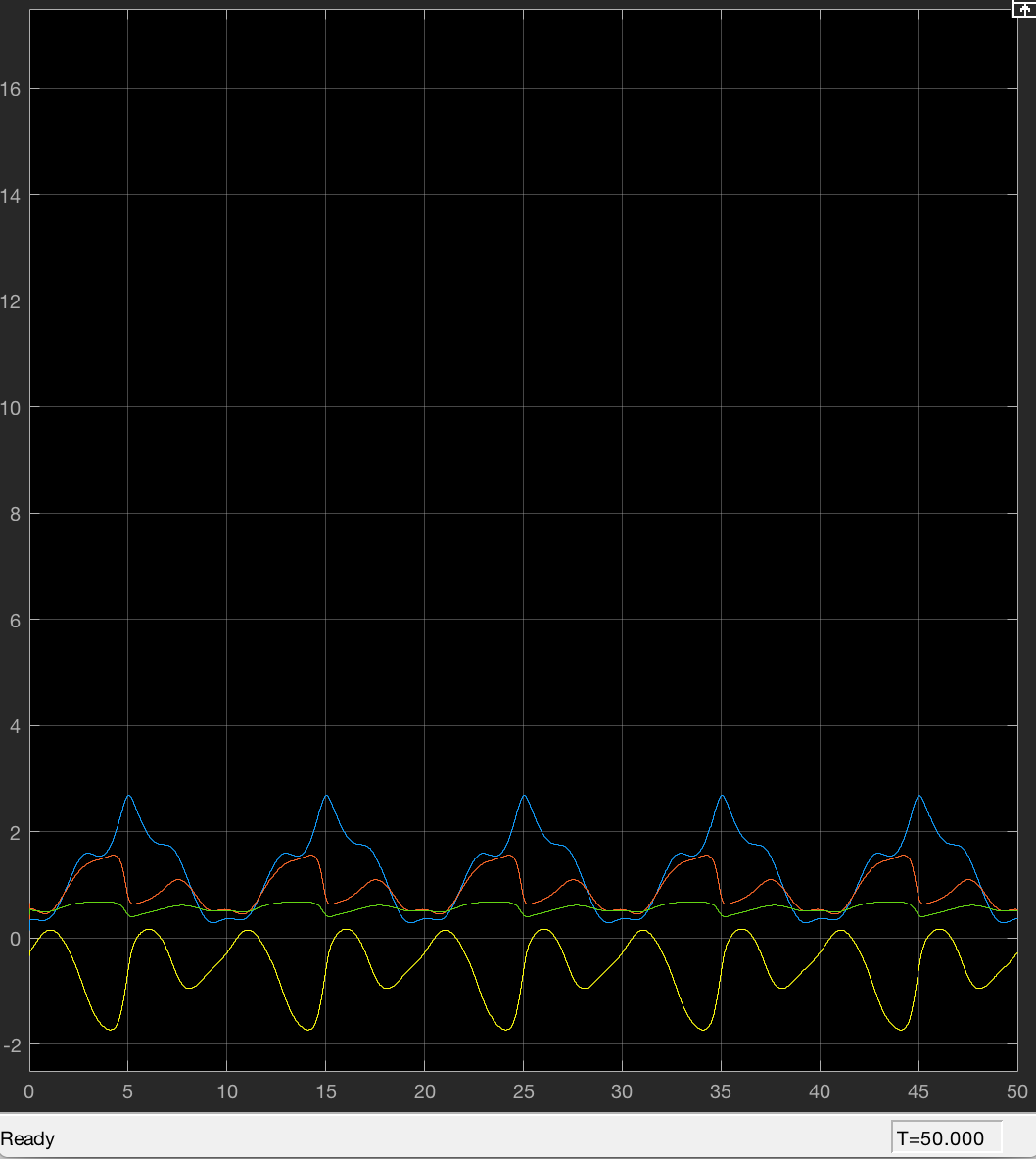




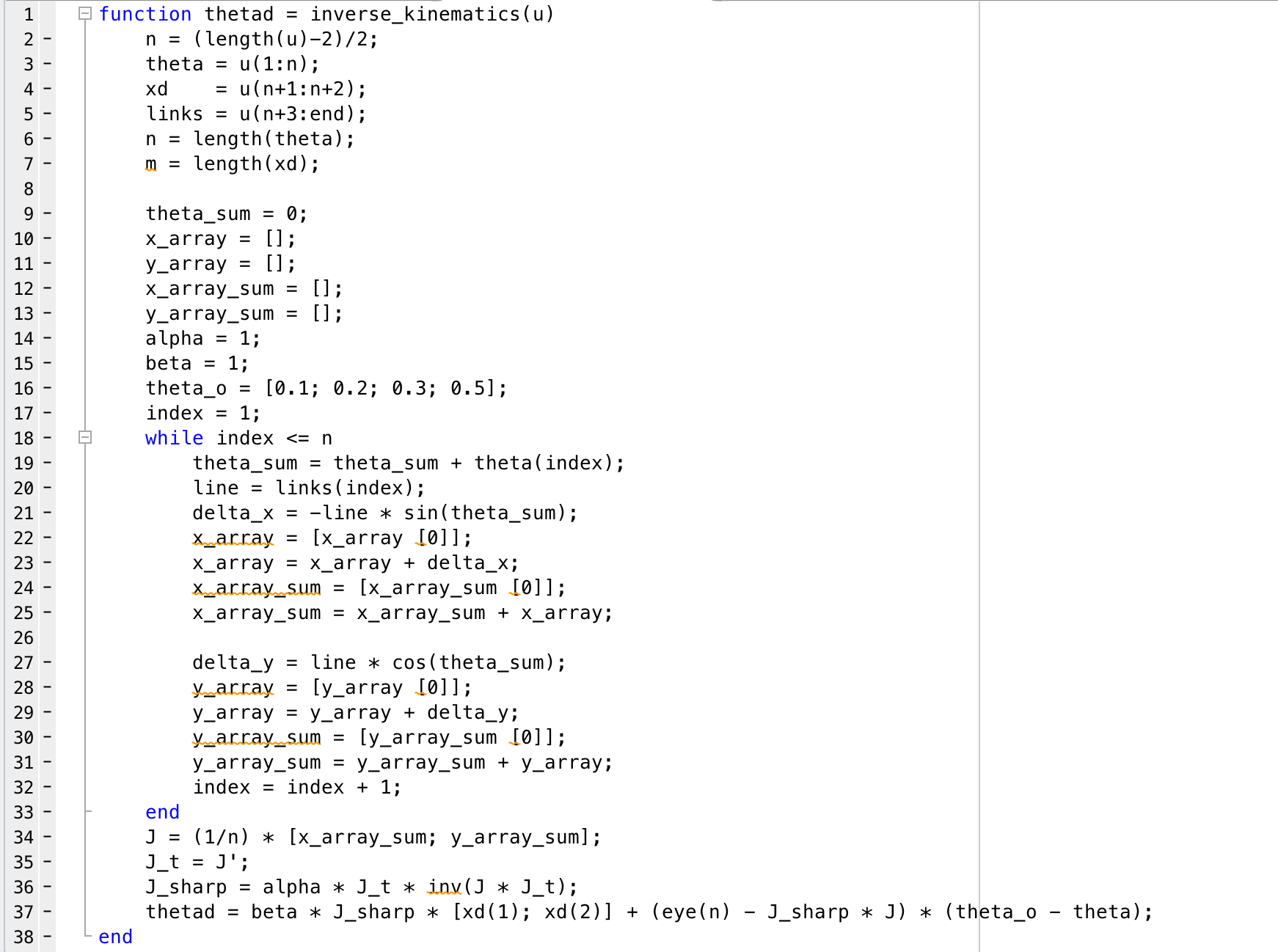
i)

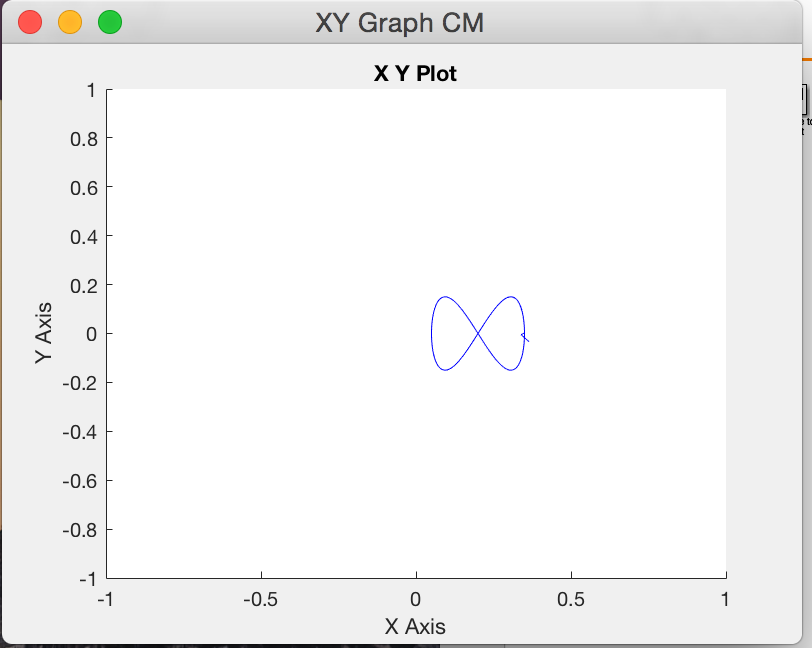


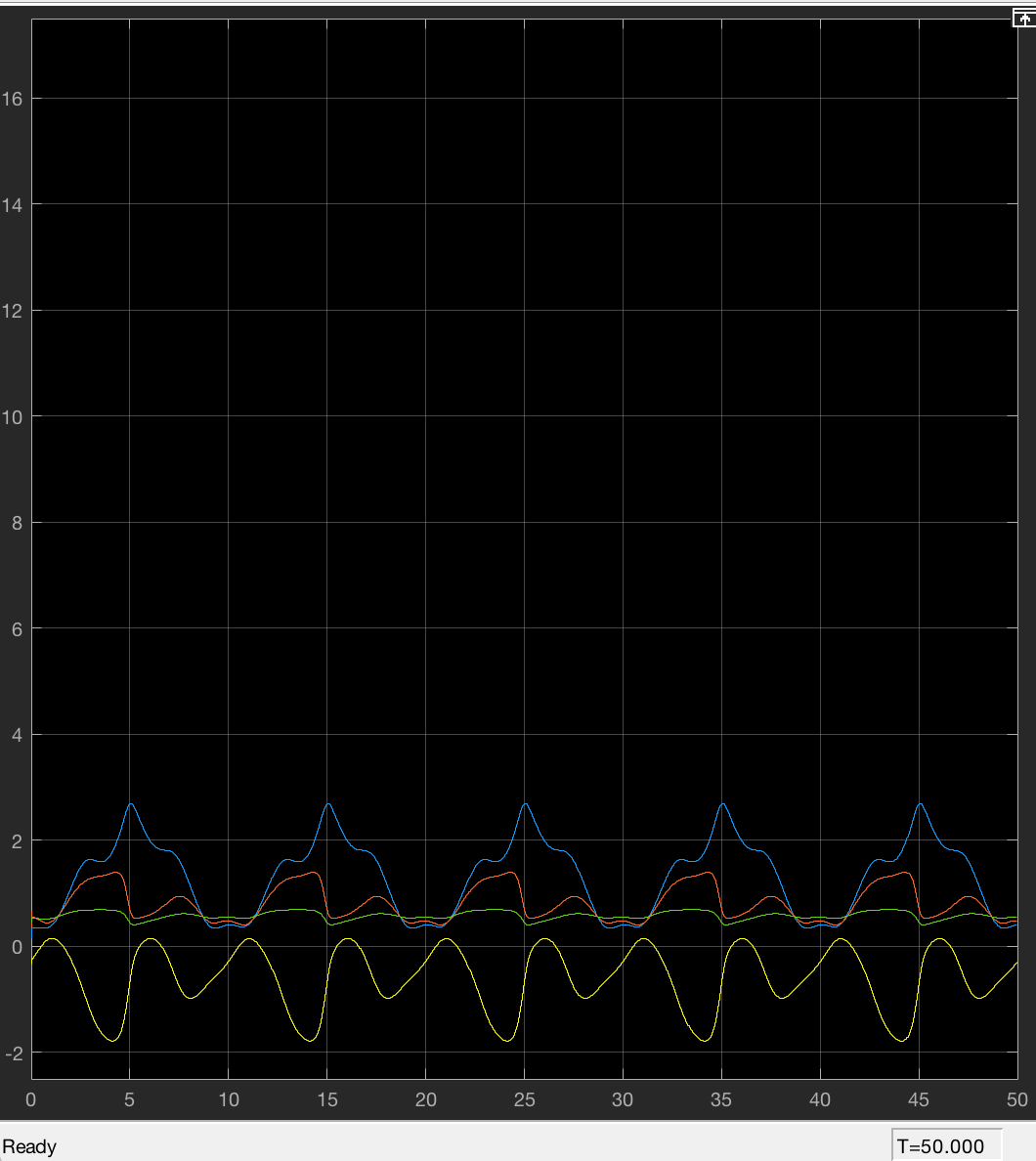




j)







j)

where is a vector of Lagrange multipliers.



Combine (1) and (2):

Insert (3) to (2):