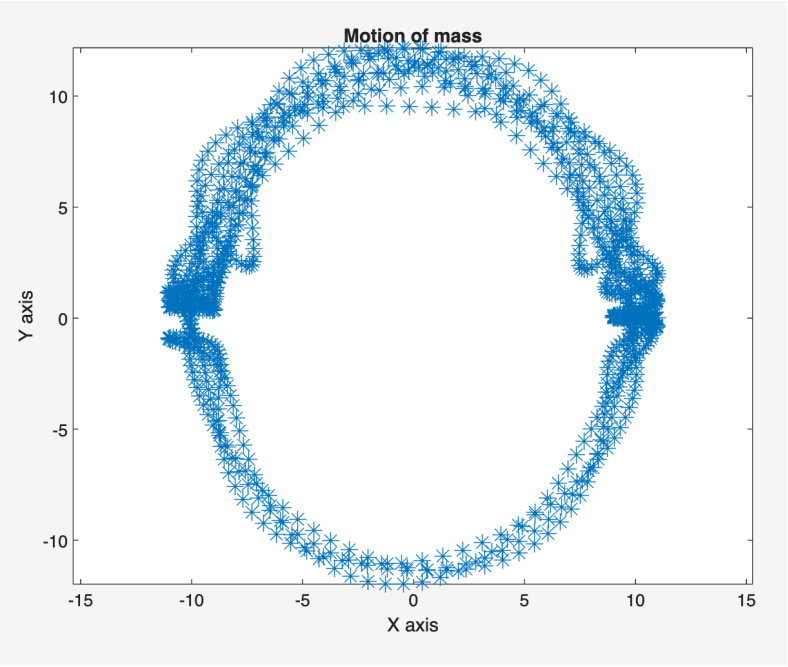
Problem 13

For the given parameters and initial guess, one equilibrium position is given below

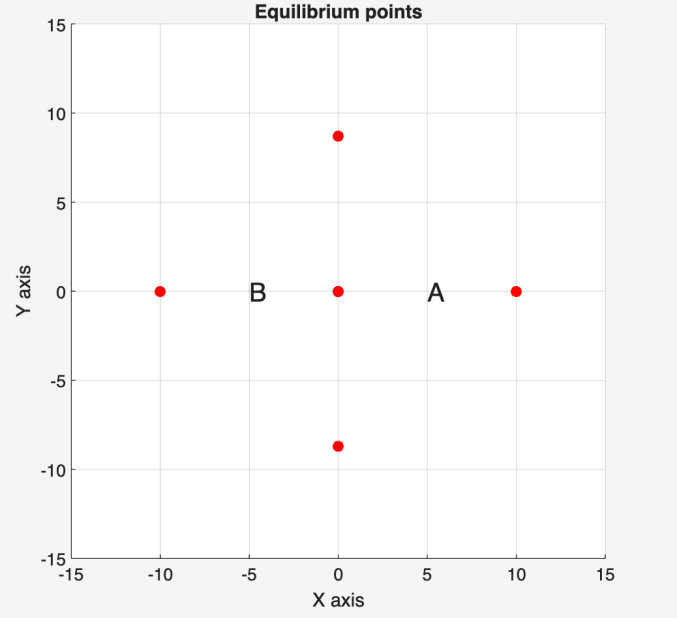
```
% Parameters and initial conditions
rA = [5 0]';
rB = [-5 0]';
kA = 50; LA = 10; cA = 0;
kB = 50; LB = 10; cB = 0;
m = 1;
g = 0;
c = 0;

% Inital guess
r0 = [11; 0.001];
v0 = [0; 0];
z0 = [r0; v0];
```

```
 The x and y equilibrium point is
    10.0000
     0.0000
```

The motion of the system for the given parameters is shown below



Equilibrium points



Maximum number of equilibrium points found were 5

```
Number of converged optimisations is 900
The 5 equilibrium points have these [x; y; vx; vy] values
Each row is one root
  -10.0000         0         0         0
         0   -8.7000         0         0
         0         0         0         0
         0    8.7000         0         0
   10.0000         0         0         0
```

From the eigenvalues of the Jacobian matrix obtained using finite differences of each state variable, the roots with no positive real eigen values are stable.

```
Root at location: x = -10 y = 0
Eigenvalues:
   0.0000 +10.0000i
   0.0000 -10.0000i
   5.7735 + 0.0000i
  -5.7735 + 0.0000i
```

```
Root at location: x = 0 y = 0
Eigenvalues:
   0.0000 +10.0000i
   0.0000 -10.0000i
  10.0000 + 0.0000i
 -10.0000 + 0.0000i
```

```
Root at location: x = 0 y = -8.7
Eigenvalues:
   0.0000 + 5.0087i
   0.0000 - 5.0087i
   0.0000 + 8.6751i
   0.0000 - 8.6751i
```

```
Root at location: x = 0 y = 8.7
Eigenvalues:
   0.0000 + 5.0087i
   0.0000 - 5.0087i
   0.0000 + 8.6751i
   0.0000 - 8.6751i
```

```
Root at location: x = 10 y = 0
Eigenvalues:
   0.0000 +10.0000i
   0.0000 -10.0000i
   5.7735 + 0.0000i
  -5.7735 + 0.0000i
```

Thus, the following equilibrium points are stable.

1. x = 0 y = -8.7
2. x = 0 y = 8.7