Vibration Lab 1 Report

Experiment with two steel beams

1. no additional mass
2. plus 572 gram mass
3. plus 1139 gram mass
4. plus 2317 gram mass

Rxperiment with one steel beam and one plastic beam

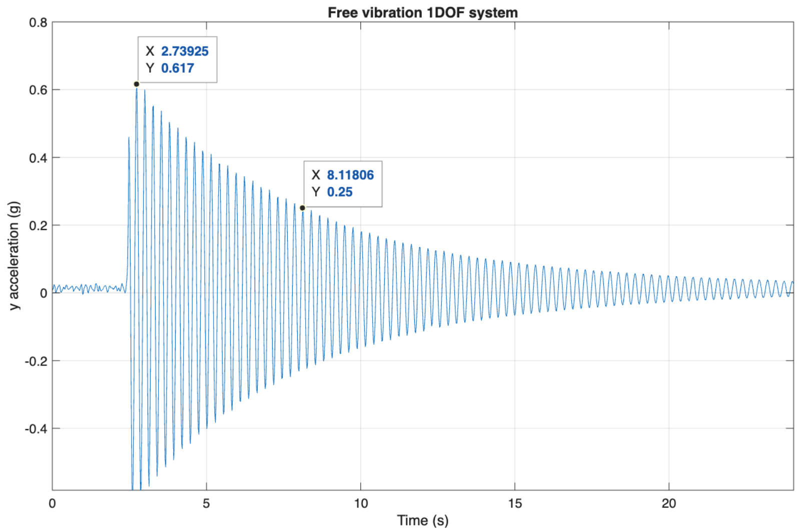
Group Number	Beam Material	Load(gram)
1	Two steel beams	None
2	Two steel beams	572
3	Two steel beams	1139
4	Two steel beams	2317
5	One steel beam and one plastic beam	572

First we want to find the damped natural frequency f_d and damped circular natural frequency ω_d

We select 20 oscillation periods and take the average to obtain T_d, Then we can get the damped natural frequency: $f_d = \frac{1}{T_d}$. Then the damped circular natural frequency can be calculated by $\omega_d = 2\pi f_d$.

Then we need to find the natural frequency f_n and natural circular frequency ω_n. From equation 2.31: $\omega_d = \sqrt(1-\zeta^2)\omega_n$, then $\omega_n = \frac{\omega_d}{\sqrt(1-\zeta^2)}$. Accordingg to equation 2.43, $\delta = \frac{2\pi\zeta}{\sqrt(1-\zeta^2)} = \frac{1}{n} ln\frac{x_0}{x_n}$. Then we get $\zeta = \frac{\delta}{\sqrt{4\pi^2+\delta^2}}$

For the first group of experiment with two steel beams and no additional mass, the plot based on experiment raw data as belows

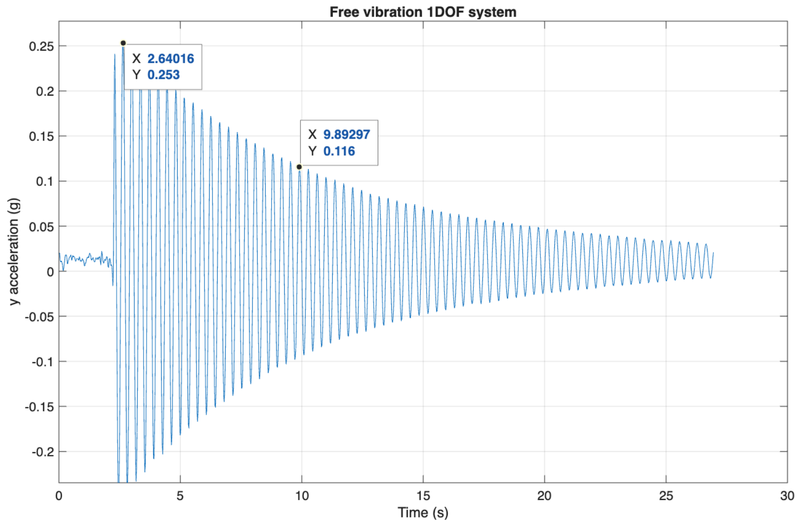


In [7]:

```
import numpy as np
from math import pi
# Calculate damped natural frequency and damped circular natural frequ
x_0 = 2.739
y_0 = 0.617
x_21 = 8.11806
y_21 = 0.25
n = 20
T_d = (x_21 - x_0) / n
f_d = 1 / T_d
w_d = 2 * pi * f_d
print(f"Damped nagural frequency for case 1: {f_d} Hz")
print(f"Damped circular natural frequency for case 1: {w_d} rad/s")
# Calculate natural frequency and natural circular frequency for case
delta = (1 / n) * np.log(y_0 / y_21)
zeta = delta / np.sqrt(4 * pi**2 + delta**2)
print(f"Damping ratio for case 1: {zeta}")
# From equation: w_d = w_n * sqrt(1 - zeta^2)
w_n = w_d / np.sqrt(1 - zeta)
f_n = w_n / (2 * pi)
print(f"Natural frequency for case 1: {f_n} Hz")
print(f"Natural circular frequency for case 1: {w_n} rad/s")
```

```
Damped nagural frequency for case 1: 3.718121753614944 Hz
Damped circular natural frequency for case 1: 23.36164797261821 rad/s
Damping ratio for case 1: 0.007188907515325551
Natural frequency for case 1: 3.731558862482265 Hz
Natural circular frequency for case 1: 23.446075817624337 rad/s
```

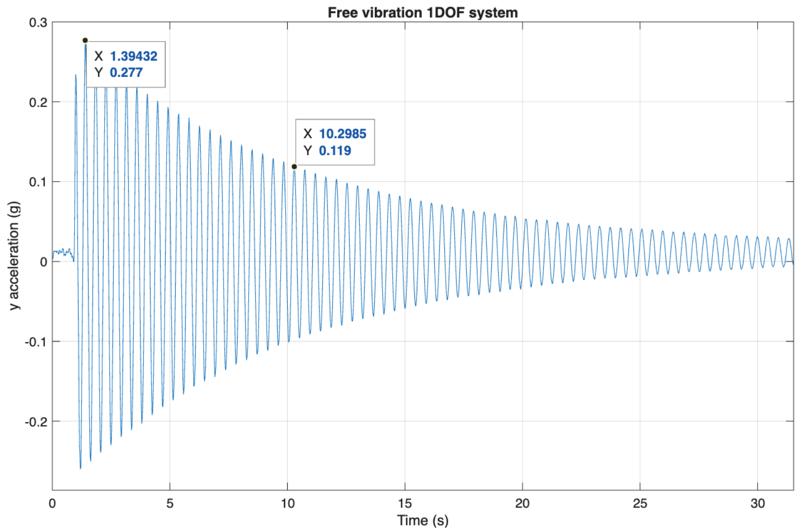
For the case 2 in experiment group one, which is two beams with a additional 572 gram mass. The result as follows:




```
In [8]: # Calculate damped natural frequency and damped circular natural frequ
x_0 = 2.64016
y_0 = 0.253
x_21 = 9.89297
y_21 = 0.116
n = 20
T_d = (x_21 - x_0) / n
f_d = 1 / T_d
w_d = 2 * pi * f_d
print(f"Damped natural frequency for case 2: {f_d} Hz")
print(f"Damped circular natural frequency for case 2: {w_d} rad/s")
# Calculate natural frequency and natural circular frequency for case
delta = (1 / n) * np.log(y_0 / y_21)
zeta = delta / np.sqrt(4 * pi**2 + delta**2)
print(f"Damping ratio for case 2: {zeta}")
# From equation: w_d = w_n * sqrt(1 - zeta^2)
w_n = w_d / np.sqrt(1 - zeta**2)
f_n = w_n / (2 * pi)
print(f"Natural frequency for case 2: {f_n} Hz")
print(f"Natural circular frequency for case 2: {w_n} rad/s")
```

```
Damped natural frequency for case 2: 2.7575519005737084 Hz
Damped circular natural frequency for case 2: 17.32620958546987 rad/s
Damping ratio for case 2: 0.006205326166978672
Natural frequency for case 2: 2.757604993354179 Hz
Natural circular frequency for case 2: 17.326543177248038 rad/s
```

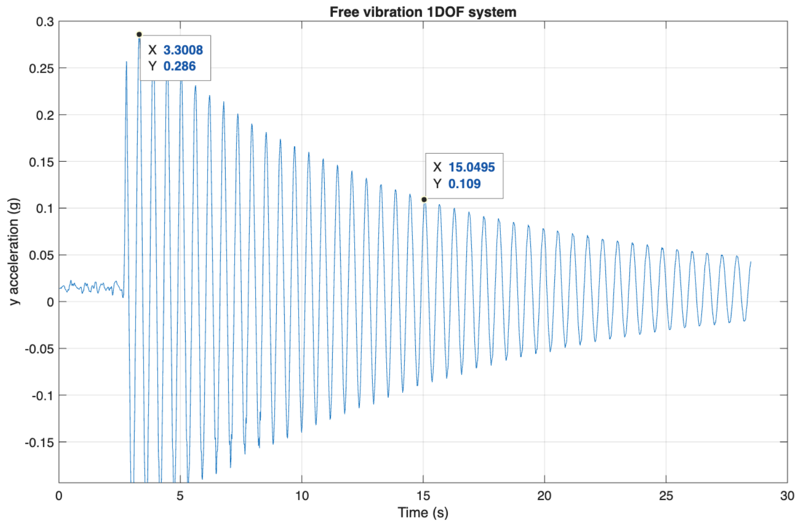
For the case 2 in experiment group one, which is two beams with a additional 572 gram mass. The result as follows:



In [9]:
```
# Calculate damped natural frequency and damped circular natural frequ
x_0 = 1.39432
y_0 = 0.277
x_21 = 10.2985
y_21 = 0.119
n = 20
T_d = (x_21 - x_0) / n
f_d = 1 / T_d
w_d = 2 * pi * f_d
print(f"Damped natural frequency for case 3: {f_d} Hz")
print(f"Damped circular natural frequency for case 3: {w_d} rad/s")
# Calculate natural frequency and natural circular frequency for case
delta = (1 / n) * np.log(y_0 / y_21)
zeta = delta / np.sqrt(4 * pi**2 + delta**2)
print(f"Damping ratio for case 3: {zeta}")
# From equation: w_d = w_n * sqrt(1 - zeta^2)
w_n = w_d / np.sqrt(1 - zeta**2)
f_n = w_n / (2 * pi)
print(f"Natural frequency for case 3: {f_n} Hz")
print(f"Natural circular frequency for case 3: {w_n} rad/s")
```

```
Damped natural frequency for case 3: 2.2461360844008094 Hz
Damped circular natural frequency for case 3: 14.112889243433052 rad/s
Damping ratio for case 3: 0.0067233009674028945
Natural frequency for case 3: 2.246186851914971 Hz
Natural circular frequency for case 3: 14.113208225132112 rad/s
```

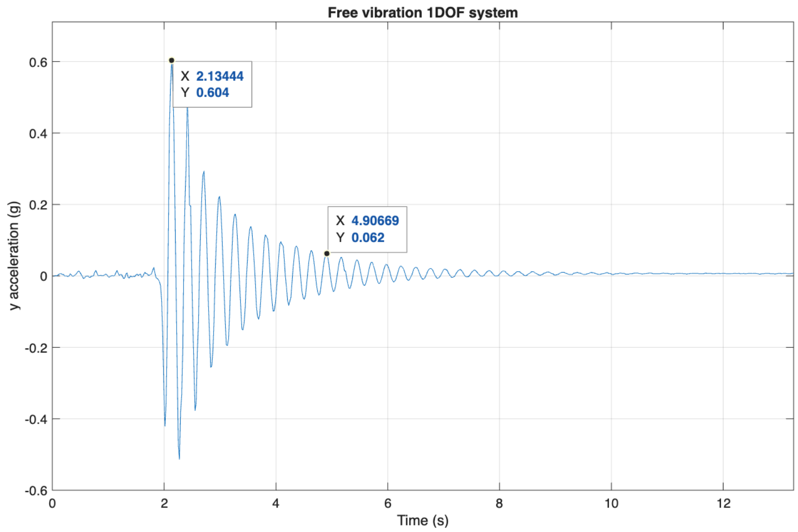
For the case 2 in experiment group one, which is two beams with a additional 572 gram mass. The result as follows:



In [10]:
```
# Calculate damped natural frequency and damped circular natural frequ
x_0 = 3.3008
y_0 = 0.286
x_21 = 15.0495
y_21 = 0.109
n = 20
T_d = (x_21 - x_0) / n
f_d = 1 / T_d
w_d = 2 * pi * f_d
print(f"Damped natural frequency for case 4: {f_d} Hz")
print(f"Damped circular natural frequency for case 4: {w_d} rad/s")
# Calculate natural frequency and natural circular frequency for case
delta = (1 / n) * np.log(y_0 / y_21)
zeta = delta / np.sqrt(4 * pi**2 + delta**2)
print(f"Damping ratio for case 4: {zeta}")
# From equation: w_d = w_n * sqrt(1 - zeta^2)
w_n = w_d / np.sqrt(1 - zeta**2)
f_n = w_n / (2 * pi)
print(f"Natural frequency for case 4: {f_n} Hz")
print(f"Natural circular frequency for case 4: {w_n} rad/s")
```

```
Damped natural frequency for case 4: 1.7023160009192508 Hz
Damped circular natural frequency for case 4: 10.695966885152547 rad/s
Damping ratio for case 4: 0.007676166314539693
Natural frequency for case 4: 1.7023661563691328 Hz
Natural circular frequency for case 4: 10.696282021138321 rad/s
```

Then came with experiment group two, which contains one steel beam and one plastic beam, plus with 572 gram mass. The result as follows:



In [6]:

```
# Calculate damped natural frequency and damped circular natural frequ
x_0 = 2.13444
y_0 = 0.604
x_11 = 4.90669
y_11 = 0.062
n = 10
T_d = (x_11 - x_0) / n
f_d = 1 / T_d
w_d = 2 * pi * f_d
print(f"Damped natural frequency for experiment with one steel beam an
print(f"Damped circular natural frequency for experiment with one stee
# Calculate natural frequency and natural circular frequency for exper
delta = (1 / n) * np.log(y_0 / y_11)
zeta = delta / np.sqrt(4 * pi**2 + delta**2)
print(f"Damping ratio for experiment with one steel beam and one plast
# From equation: w_d = w_n * sqrt(1 - zeta^2)
w_n = w_d / np.sqrt(1 - zeta**2)
f_n = w_n / (2 * pi)
print(f"Natural frequency for experiment with one steel beam and one p
print(f"Natural circular frequency for experiment with one steel beam
```

```
Damped natural frequency for experiment with one steel beam and one pla
stic beam: 3.6071782847867255 Hz
Damped circular natural frequency for experiment with one steel beam an
d one plastic beam: 22.664569599349214 rad/s
Damping ratio for experiment with one steel beam and one plastic beam:
0.036206908980475974
Natural frequency for experiment with one steel beam and one plastic be
am: 3.6095450096327744 Hz
Natural circular frequency for experiment with one steel beam and one p
lastic beam: 22.679440170128046 rad/s
```