MODULE CODE : SME 3701
STUDENT NUMBER : 43728200

QUESTION 1

GIVEN DATA :

Length $m = 1.5\,m$
FLEXURAL Rigidity $EI = 80\ Nm^2$
Harmonic Force applied $F(t) = 10 \sin(20t)$ at $x = \frac{L}{2}$
Mass per unit length $m = 0.4\ kg/m$

INFORMATION BELOW WERE SOURCED FROM REFERENCE [1]
FORCED DAMPED VIBRATION OF EULER BERNOULLI BEAM
GOVERNING DIFFERENTIAL EQUATION OF MOTION:

$$EI \frac{\partial^4 w(x,t)}{\partial x^4} + C \frac{\partial(x,t)}{\partial t} + m \frac{\partial^2 w(x,t)}{\partial t^2} = F(x,t)$$

WHERE:

$w(x,t)$ REPRESENTS TRANSVERSE DISPLACEMENT.
$F(x,t)$ WAS THE EXTERNAL APPLIED FORCE.

FIRST MODE NATURAL FREQUENCY

$$\omega_1 = \pi^2 \sqrt{\frac{EI}{mL^4}} = \pi^2 \sqrt{\frac{80}{(0.4)(1.5)^4}} = \underline{62.034\ rad/s}$$

$$f_1 = \frac{\omega_1}{2\pi} = \frac{62.034}{2\pi} = \underline{9.87\ Hz}$$

FIRST MODE PARAMETERS

Mass $M_1 = \frac{mL}{2} = \frac{0.4 \times 1.5}{2} = \underline{0.3\ kg}$

Stiffness $K_1 = \omega_1^2 M_1 = (62.034)^2(0.3) = \underline{1154.465\ N}$

Force $F = 10(\sin 90^\circ) = 10\ N$ APPLIED AT $x = \frac{L}{2}$

TO CALCULATE DAMPING CONSTANT $\xi = 0.02$ WAS ASSUMED FOR DAMPING TO OCCUR NORMAL

$$C_1 = 2\xi\omega_1 M_1 = 2(0.02)(62.034)(0.3) = 0.744$$

SINGLE DEGREE OF FREEDOM EQUATION OF MOTION:

$$M_1\ddot{x} + C_1\dot{x} + Kx = F_0 \sin \omega t$$

$$0.3\ddot{x} + 0.744\dot{x} + 1153.465x = 10 \sin(20t)$$

EQUATION ARRANGEMENT FOR SIMULINK MODELLING

EQUATION OF MOTION $= m\ddot{x} + c\dot{x} + kx = F(t)$

$$\ddot{x} = \frac{1}{m}\left(f(t) - c\dot{x} - kx\right)$$

[1.1] Sinusoidal Input Model

Fig.1. Simulink Model – Block diagram

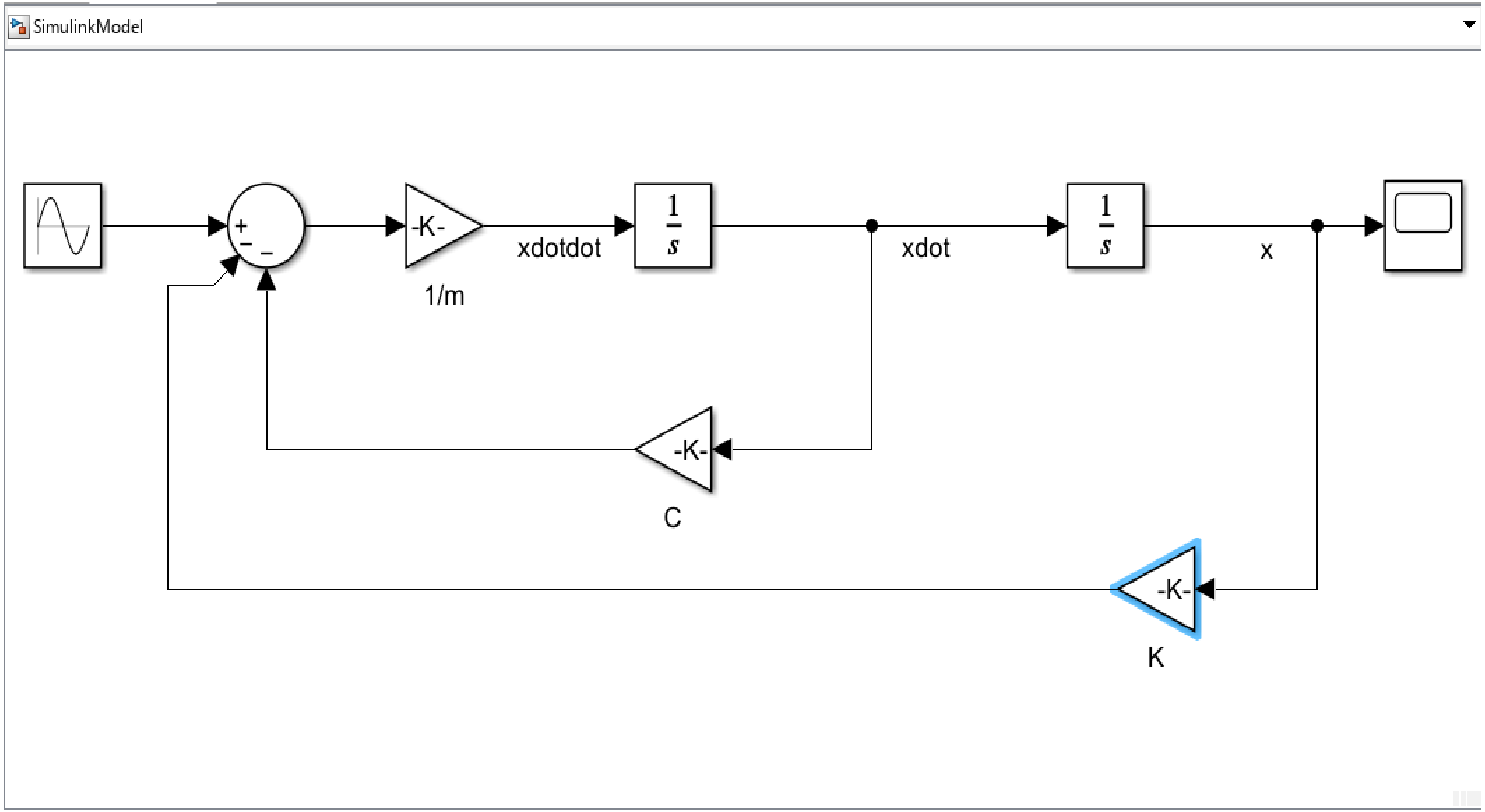
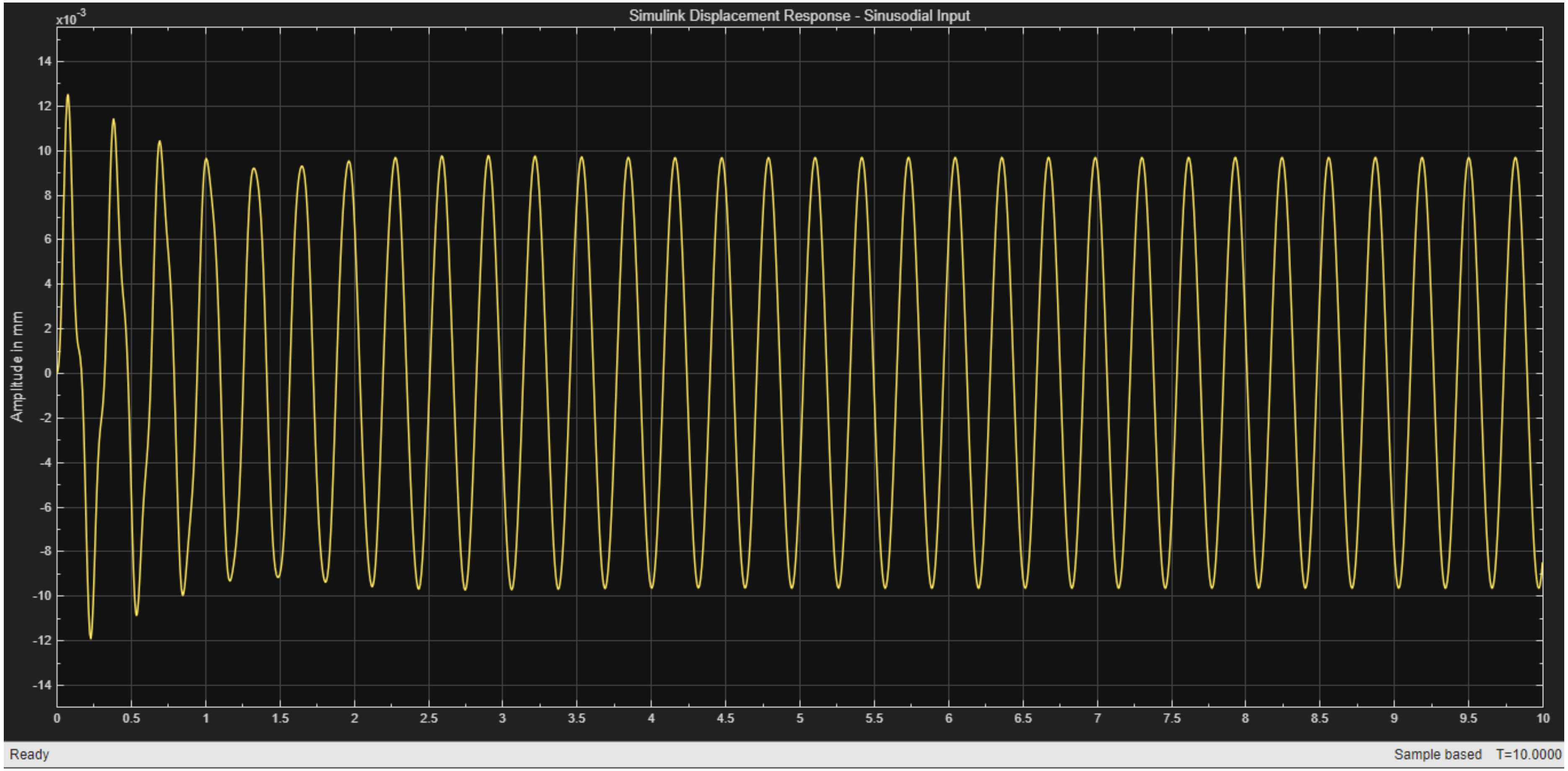


Fig.2. Simulation diagram – displacement response



Time in (Seconds)

[1.2]. Chip Signal Input Model - Frequency Sweep

Fig 3. Simulink Model – Block diagram.

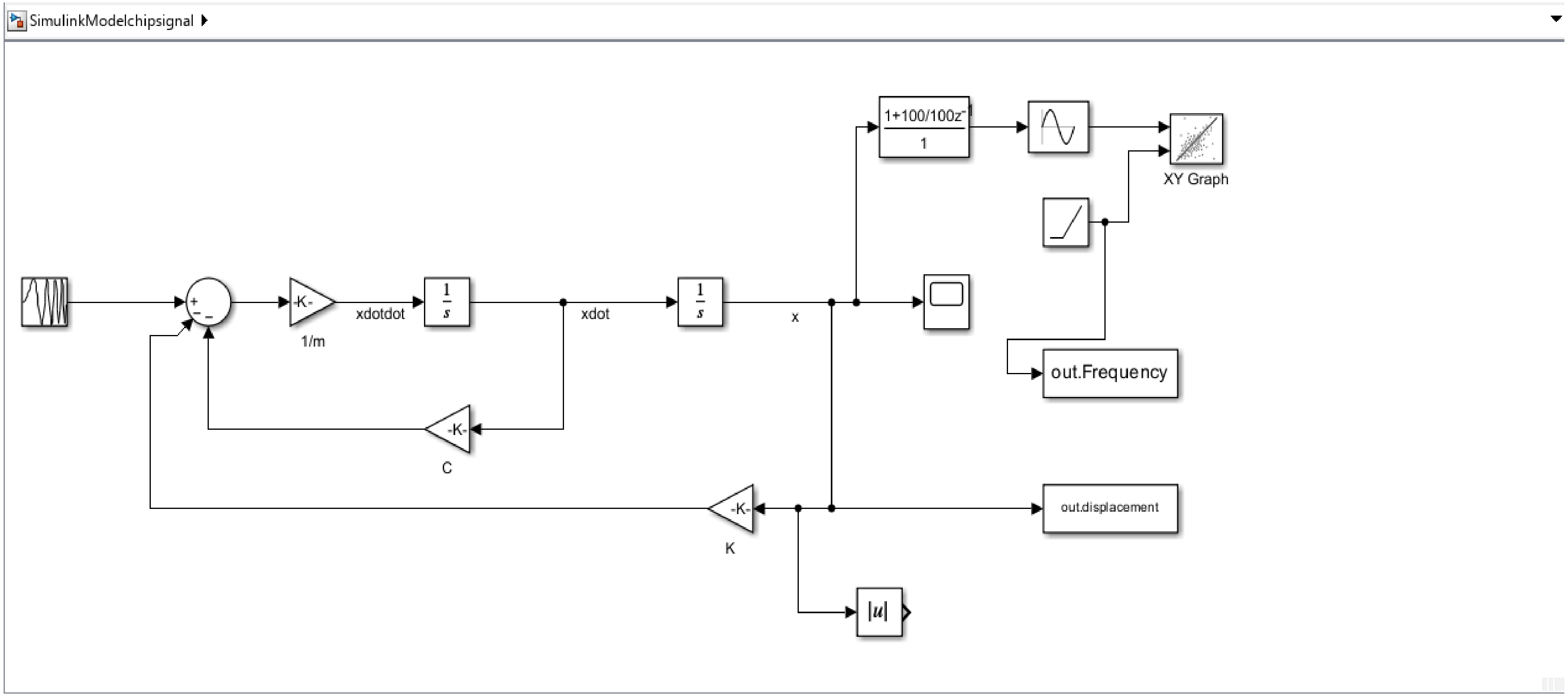
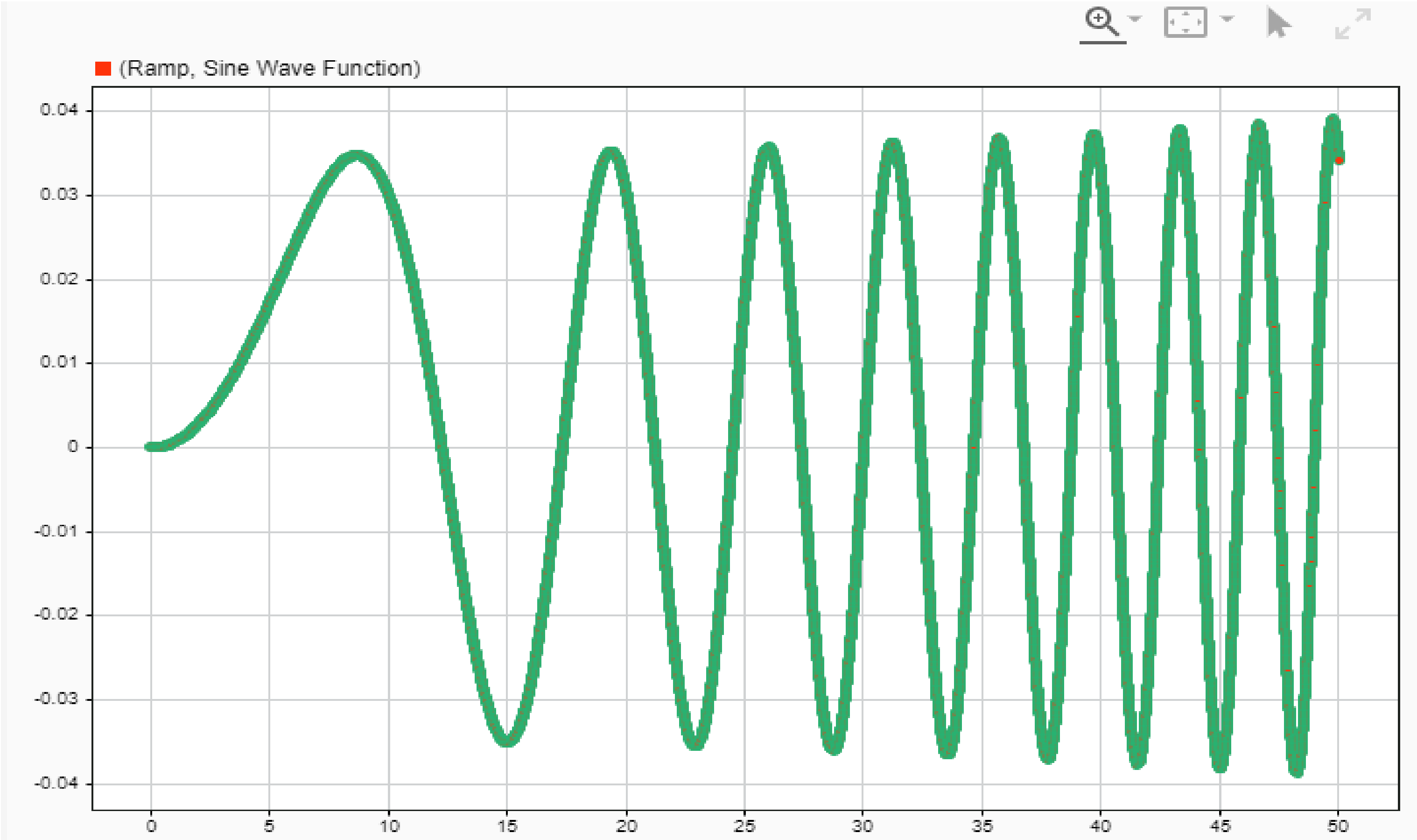


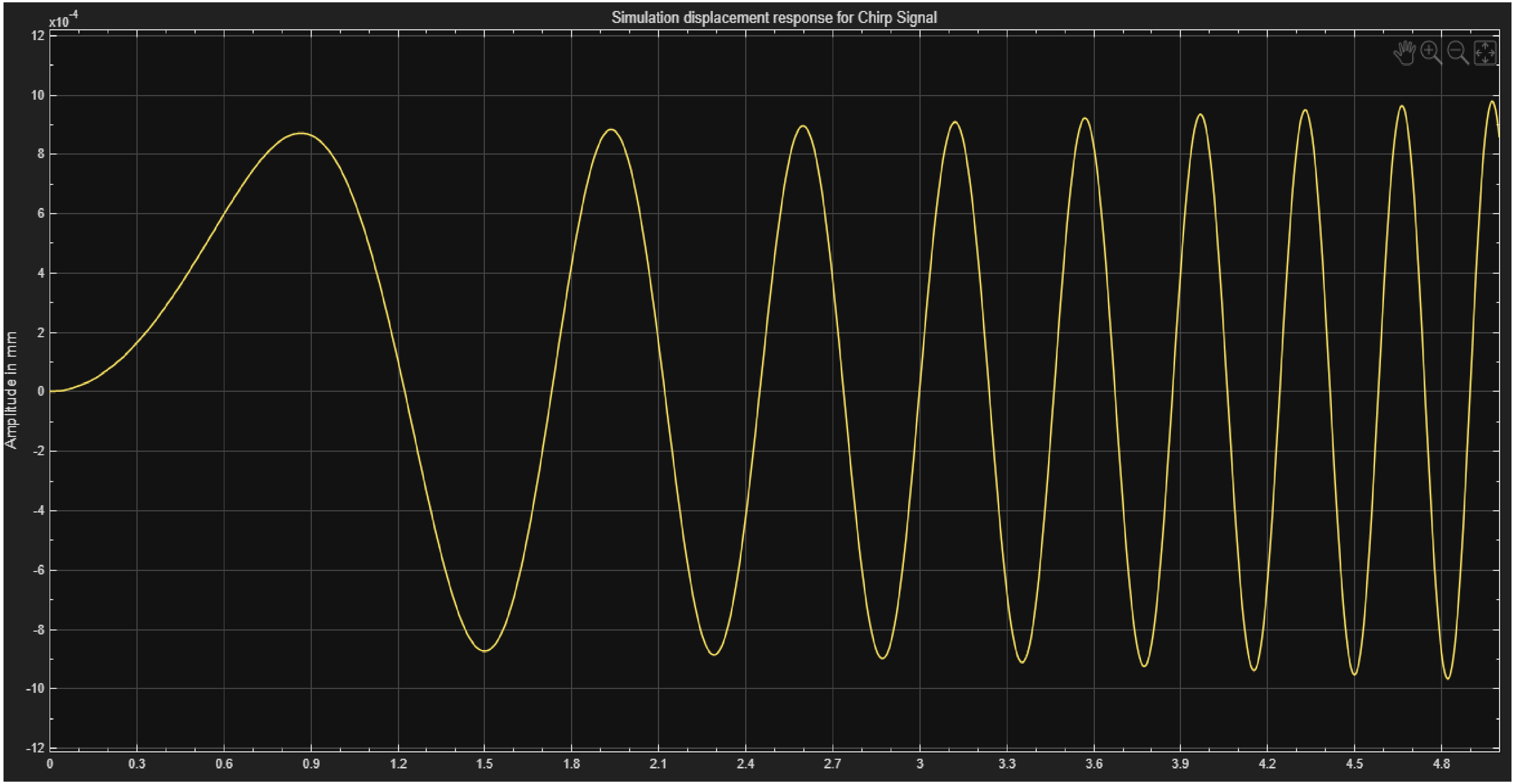
Fig.4. Simulink Simulation Displacement vs Forcing Frequency XY plot – for Chirp Input Signal

Amplitude (mm)



Forcing frequency in rad/sec

Fig.5. Simulink Simulation diagram - for Chirp Signal Frequency Sweep.



Time in seconds

References.

[1]. Prof. W. T Thomson, Theory pf Vibration with Applications, 4^{th} Ed. Taylor and Francis,2 Madison Ave, NEW YORK, NY, USA, 2003.pp 268-406.

[2]. Z. Masound. Mechanical Vibrations, 3 Jun. 2021, *Matlab Simulink Model of a Spring-Damper-Damper System*. YouTube. [Video]. online. Available: https://youtu.be/pcRJerq6Aqa?si=3CZHNtueSuja6y.[Accessed 16 October 2025].

[3] Prof. S. Talukdar, Lecture 19 – *Forced Damped Vibration analysis of Euler Bernoulli Beams*, 27 Jan. 2023. Vibration of Continuous Systems. YouTube. [Video]. online. Available: https://youtu.be/3SX_KOGi4Qo?si=CWWzLUyjsslW. [Accessed 15 October].

[3] Prof. S. Talukdar, Lecture 16 – *Transverse Vibration of Beams*, 27 Jan. 2023. Vibration of Continuous Systems. YouTube. [Video]. online. Available: https://youtu.be/2yynypal_D0?si=fz1vAidcQbnfew91 . [Accessed 14 October].

[4] Prof. S. Talukdar, Lecture 17 – Natural Frequencies and Mode shapes of Beams with various end conditions, 27 Jan. 2023. Vibration of Continuous Systems. YouTube. [Video]. online. Available: https://youtu.be/YzUv7NQOhsE?si=kn43i19POpJ7-Won .[Accessed 14 October].