ME748: Computer Aided Simulation of Machines

Term Project 2: Static and Dynamic Analysis

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Abstract

Here, the (virtual) model created in Term Project 1 is used to perform a static force analysis and verify the results by manual computation. Then perform a dynamic motion analysis for varying force/torque profiles.

Contents

1   Static Force Analysis

A constant force (in a constant global direction) should be applied to a specific point of the output component and the force/torque needed at the driving component to keep/hold the mechanism in this position under this condition needs to be obtained from the software. This should be done with the mechanism in four positions, preferably the same four positions which were used for theoretical evaluation of kinematic parameters in Term Project 1. The point and direction of application of this force should be shown in four snapshots.

1. Position 1 In fig 1, the white arrow indicates the force applied on the output link whose magnitude
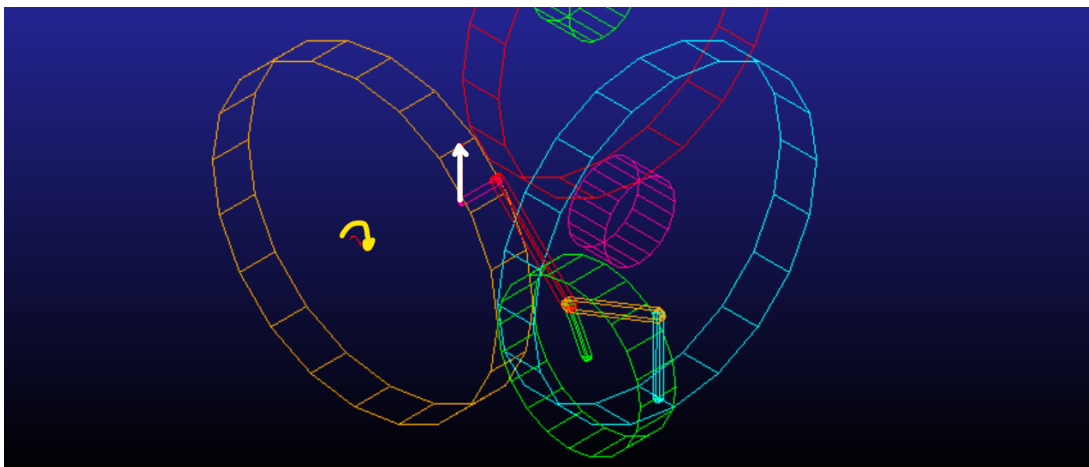

Fig. 1: Mechanism and Force applied

is 50 kg-mm/s$\hat{2}$. And the yellow curved arrow indicates the torque applied to prevent the system

Fig. 2: Output displacement vs time

from moving which comes out to be -5500 kg-mm$\hat{2}$/s$\hat{2}$. Output displacement plot is shown in fig 2, which is constant that indicates the applied torque at the input gear prevents the output link from moving.

2   Validation of static force analysis

A manual validation of the static force analysis for any one of the values reported in Section 1. See fig 3 and fig 4.

3   Dynamic motion analysis

3.1   Constant driving force/torque

3.1.1   Velocity and Acceleration

Providing a constant input torque of 5500 kg-mm$\hat{2}$/s$\hat{2}$ clockwise.

1. Velocity plot is shown in fig 5

2. Acceleration plot is shown in fig 6

3.1.2   Sub2

Applying twice the torque applied in previous section i.e. -11000 kg-mm$\hat{2}$/s$\hat{2}$. Superimposed plots are shown below.

1. Velocity plot is show in fig 7

2. Acceleration plot is shown in fig 8

3.2   Sinusoidal driving force/torque

Now we apply sinusoidal torque $T = 1.4 * 5500 * (1 + \sin(40t))$. The force graph has been shown in fig 9.

1. Velocity plot is shown in fig 10

2. Acceleration plot is shown in fig 11

References

[1] Liang Sun, Xuan Chen, Chuanyu Wu, Guofeng Zhang, Yadan Xu, *Synthesis and design of rice pot seedling transplanting mechanism based on labeled graph theory*, Computers and Electronics in Agriculture, Vol. 143, 2017, Pages 249-261, ISSN 0168-1699, https://doi.org/10.1016/j.compag.2017.10.021
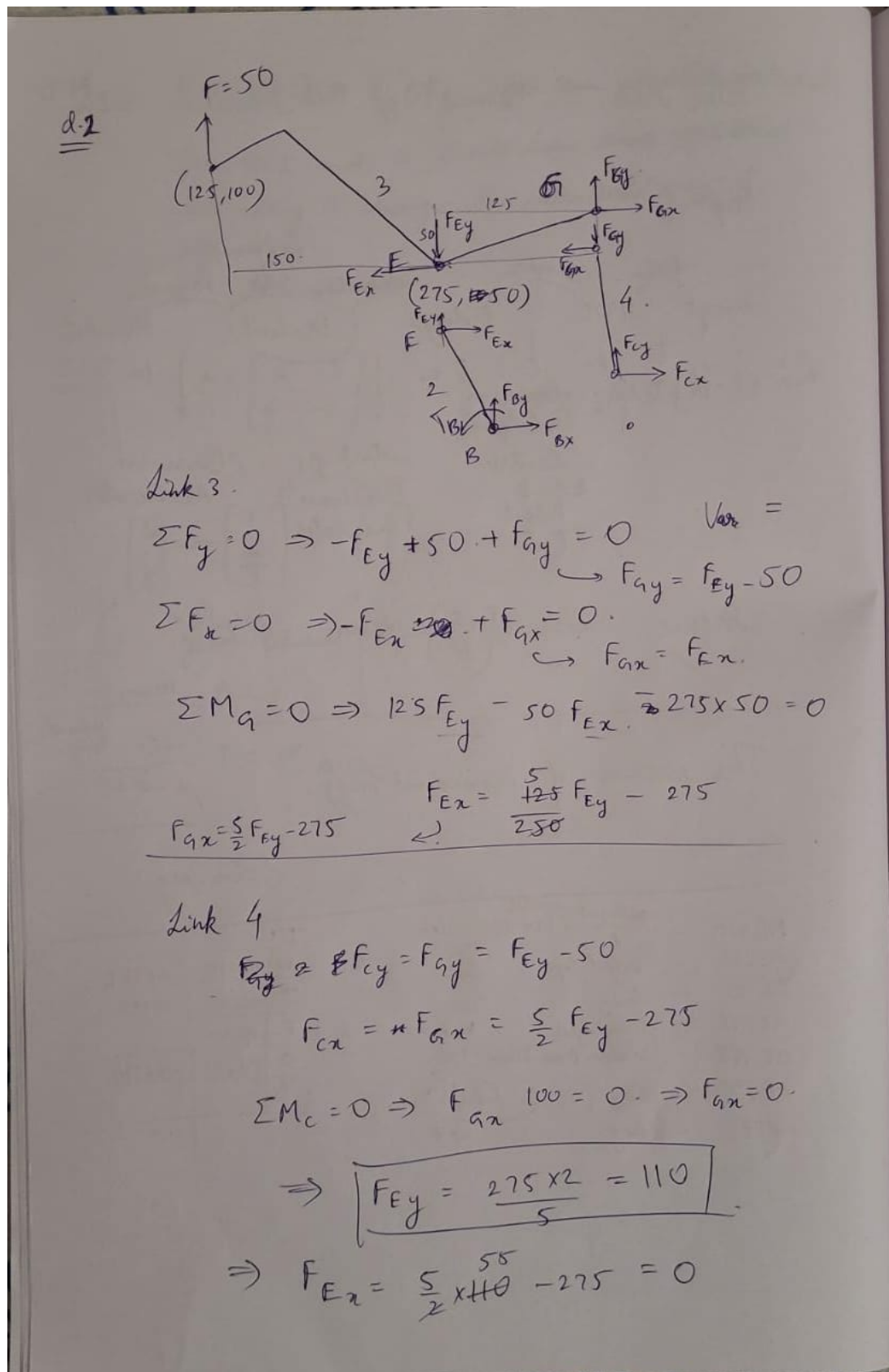
Fig. 3: page1

d.2

$F = 50$

$(125, 100)$

3

$(275, \cancel{1}50)$

Link 3.

$$\Sigma F_y = 0 \Rightarrow -f_{Ey} + 50 + f_{Gy} = 0$$
$$\hookrightarrow F_{Gy} = F_{Ey} - 50$$

$$\Sigma F_x = 0 \Rightarrow -f_{Ex} + f_{Gx} = 0.$$
$$\hookrightarrow F_{Gx} = f_{Ex}.$$

$$\Sigma M_G = 0 \Rightarrow 125\, F_{Ey} - 50\, f_{Ex} - 275 \times 50 = 0$$

$$F_{Ex} = \frac{\overset{5}{\cancel{125}}}{\cancel{250}} F_{Ey} - 275$$

$$F_{Gx} = \frac{5}{2} F_{Ey} - 275$$

Link 4

$$F_{Cy} = f_{Gy} = F_{Ey} - 50$$

$$F_{Cx} = F_{Gx} = \frac{5}{2} f_{Ey} - 275$$

$$\Sigma M_C = 0 \Rightarrow F_{Gx} \, 100 = 0. \Rightarrow F_{Gx} = 0.$$

$$\Rightarrow \boxed{F_{Ey} = \frac{275 \times 2}{5} = 110}$$

$$\Rightarrow F_{Ex} = \frac{5}{2} \times \overset{55}{\cancel{110}} - 275 = 0$$

[2] Yadav, Dr & Mital, Patel & P, Shukla & Pund, Sahastrarashmi. (2007). *Ergonomic evaluation of manually operated six-row paddy transplanter.* International Agricultural Engineering Journal. 16.
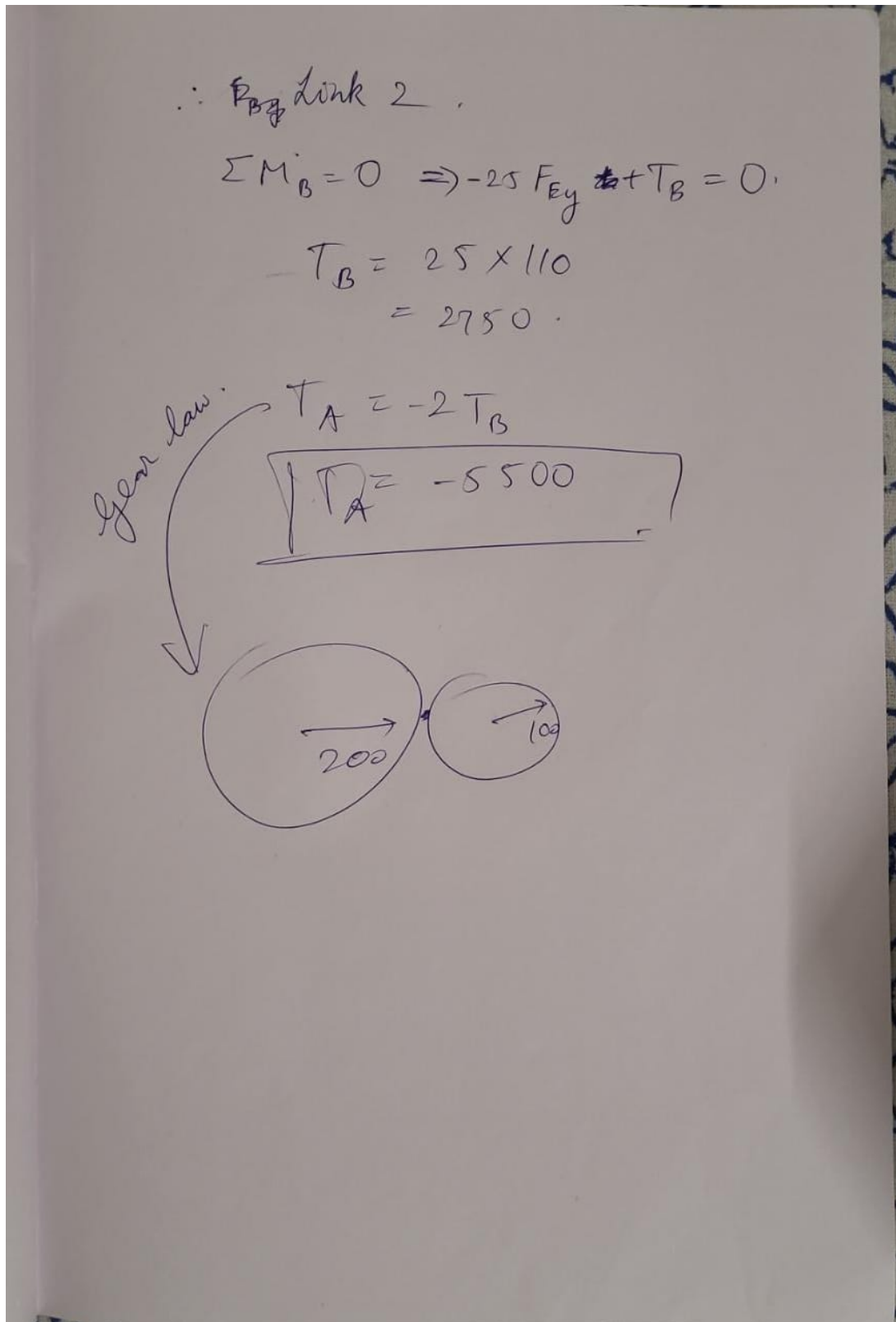
$$\therefore F_{B} \text{ Link 2}.$$

$$\sum M_{B} = 0 \implies -25\, F_{Ey} + T_{B} = 0.$$

$$T_{B} = 25 \times 110$$

$$= 2750.$$

Gear law.

$$T_{A} = -2\, T_{B}$$

$$\boxed{T_{A} = -5500}$$

200   100

Fig. 4: page2

147-157.

[3] Guru, Prabhat & Chhuneja, Naresh & Dixit, Anoop & Tiwari, Prem & Kumar, Anjani. (2018). *Mechanical transplanting of rice in India: Status, technological gaps and future thrust.* ORYZA- An International Journal on Rice. 55. 10.5958/2249-5266.2018.00012.7.
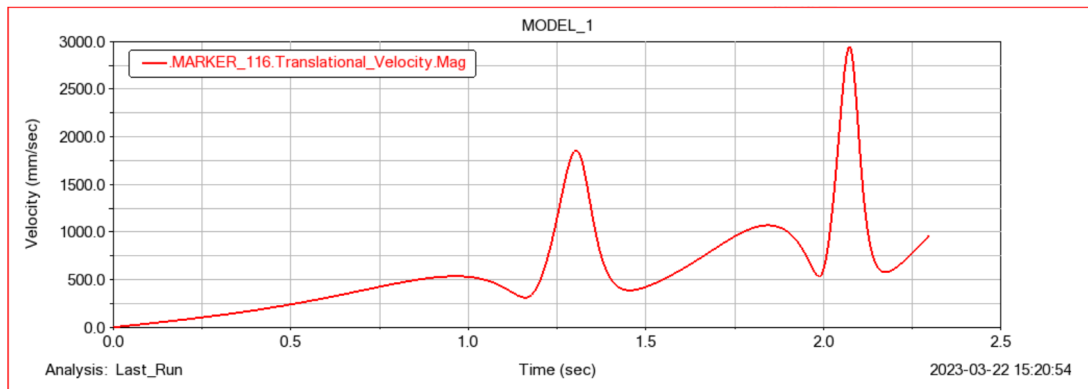
Fig. 5: Velocity vs time
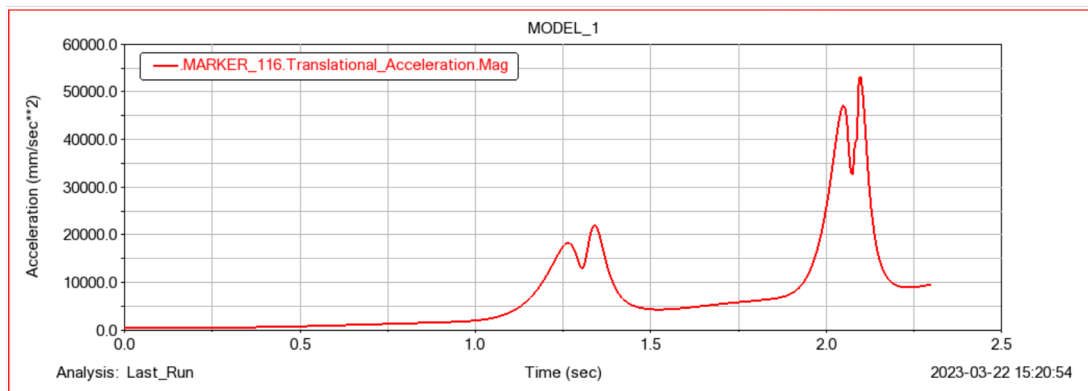
Fig. 6: Acceleration vs time
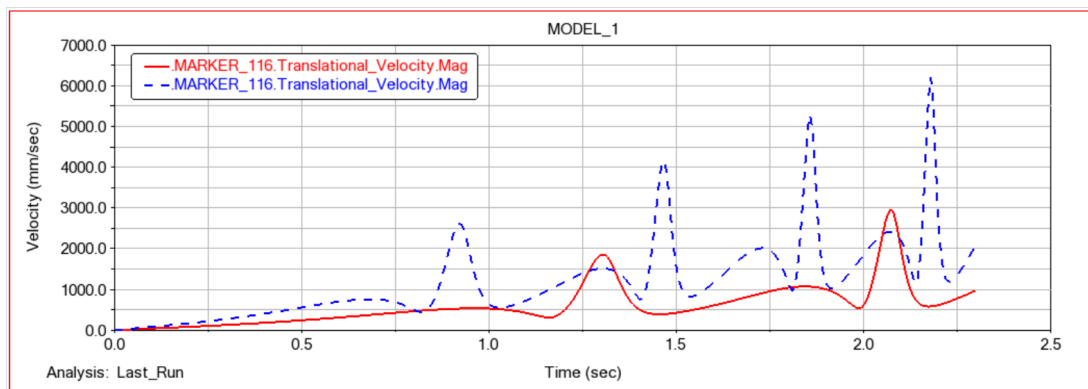
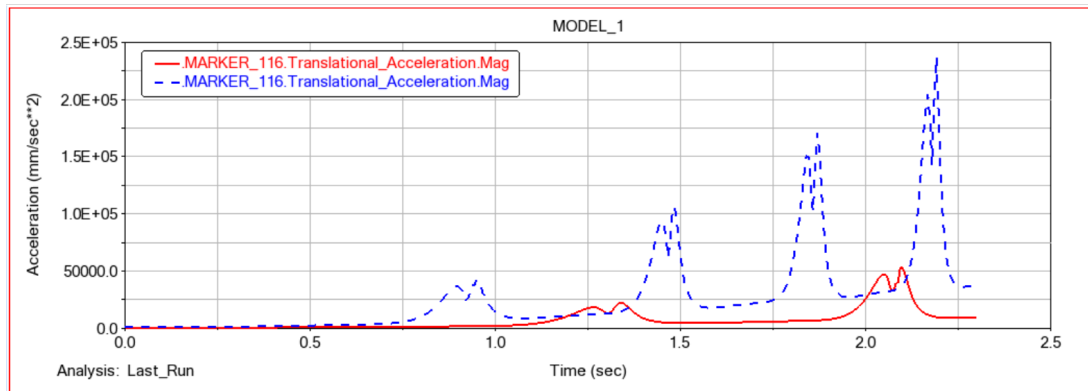Fig. 7: Superimposed velocity vs time
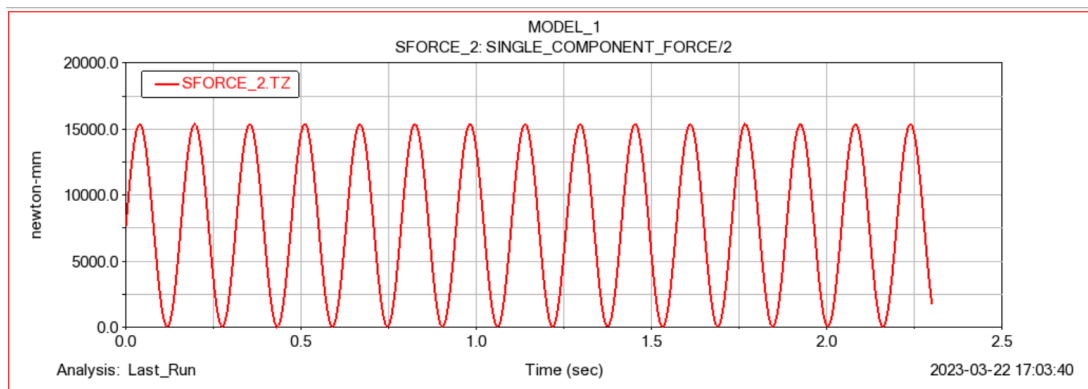
Fig. 8: Superimposed acceleration vs time
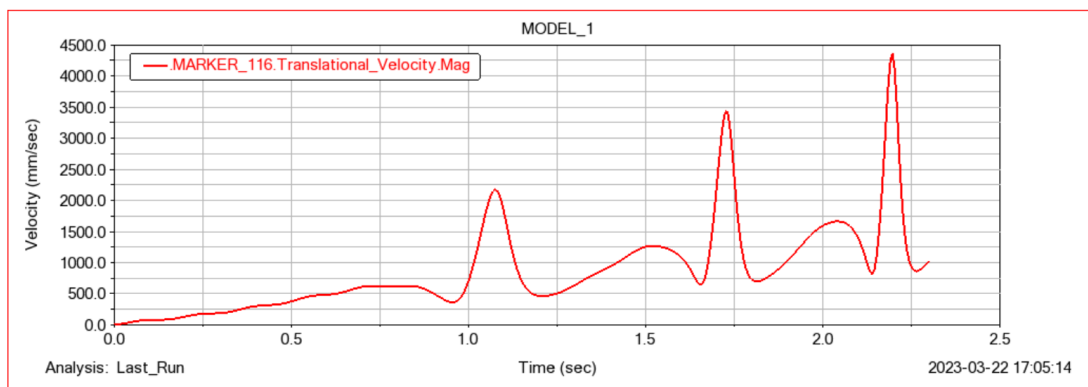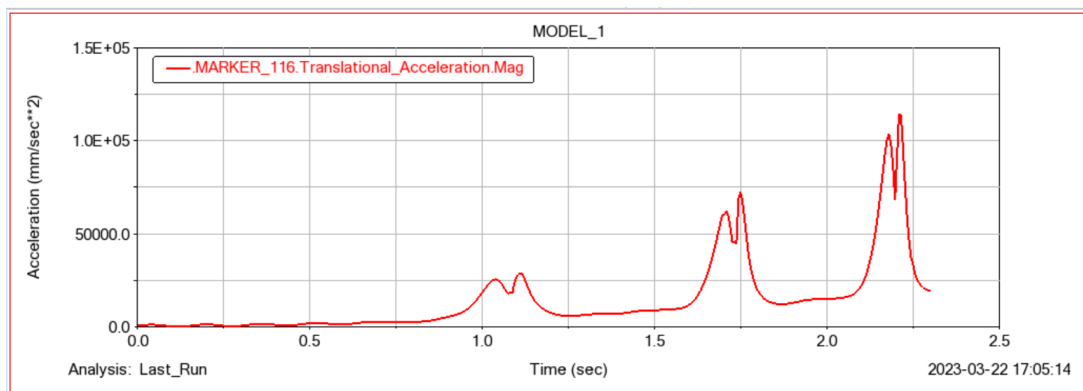
Fig. 9: Sinusoidal force vs time

Fig. 10: Velocity for sine force vs time

Fig. 11: Acceleration for sine force vs time