Program Overview

Given a road profile, calculate the response of the Mazda Miata MX-5's spring suspension system with input parameters *m* (mass), *b* (damping), *k* (spring constant), and *v* (velocity).

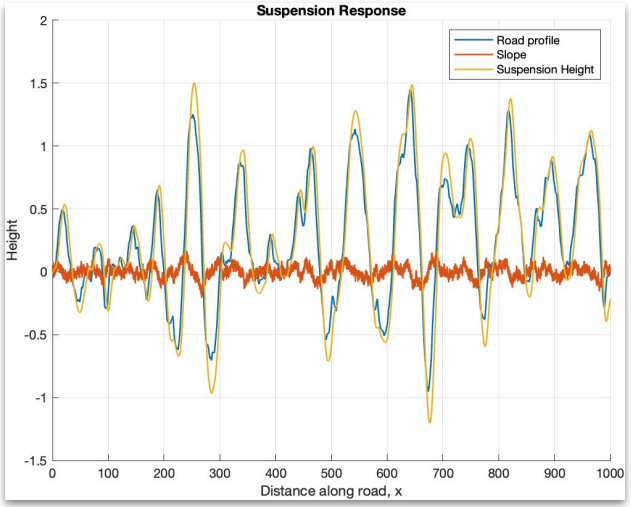

Figure 1. Calculated suspension height given a road profile. The 'poor road' profile was used for this demonstration.

```
Command Window
  Max spring extenison: 4.360345e-01
  Max spring compression: -5.527325e-01
  Max accelration of car body: 3.068858e-02
fx >>
```

Figure 2. Computed maximum compression and extension of spring for same 'poor road' profile. Acceleration of the car body was also computed.

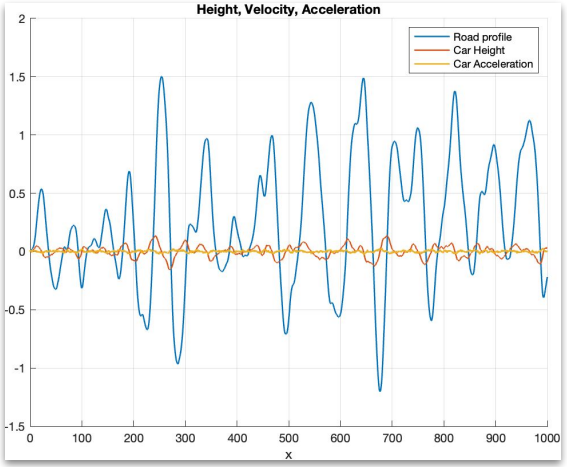

Figure 3. A plot of the acceleration undergone by the car body over the course of its journey over the poor road profile.

Result Verification

$$x_p(t) = h\sqrt{\frac{1+\left(2\zeta\frac{\omega}{\omega_n}\right)^2}{\left(1-\frac{\omega^2}{\omega_n^2}\right)^2+\left(2\zeta\frac{\omega}{\omega_n}\right)^2}}\cos(\omega t+\phi+\psi),$$

Equation 1. Response of car riding over sinusoidal road profile.

Using a previously studied road profile (sinusoidal) for which the spring response can be reliably plotted using Eq. (1), we can plot our code's computed response at different input velocities against the expected response.

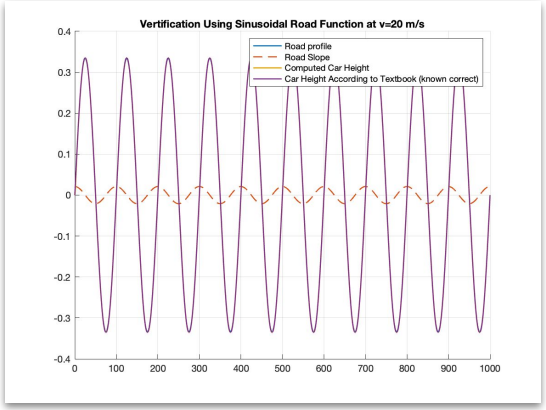

Figure 4. Sinusoidal road profile test at *v=20m/s*. The blue, yellow, and purple lines are perfectly overlapping for the entire length of the road. The near-perfect 'tracing' of the road profile at low speeds is expected.

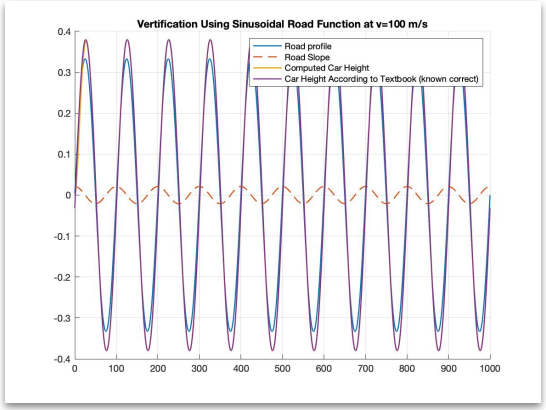

Figure 5. Test at *v=100m/s*. The yellow and purple lines (i.e., expected and computed responses) are almost perfectly overlapping for the entire length of the road.

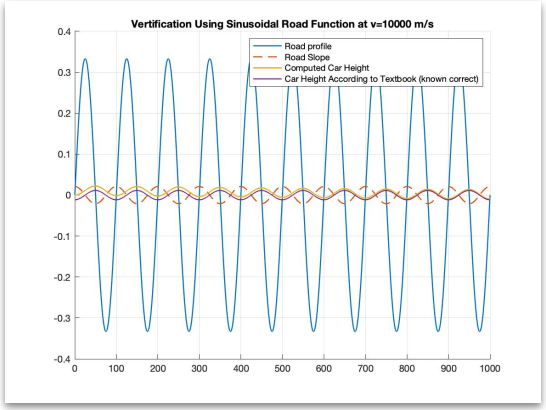

Figure 6. Test at *v=10000m/s*. The yellow and purple lines are almost perfectly overlapping for the entire length of the road. Their small magnitude makes sense because at high speeds, the car 'skims' the surface of the bumps (i.e. very small displacement).

Magnitude Verification

The magnification factor of the magnitude of response expected by the spring is plotted in Fig. 7. The three highlighted points correspond to the three velocities tested in Fig. 4, Fig. 5, and Fig. 6, respectively.

A	B	C	D	E
Velocity	**Magnitude of road sin function**	**Computed magnitude of spring response**	**Computed magnification (column C divided by column B**	**Expected magnification**
20 m/s	0.333	0.333	1.00	1.01
100 m/s	0.333	0.378	1.15	1.14
10000 m/s	0.333	0.0114	0.0345	0.0342

The expected and computed magnifications match, so our model is reliable.

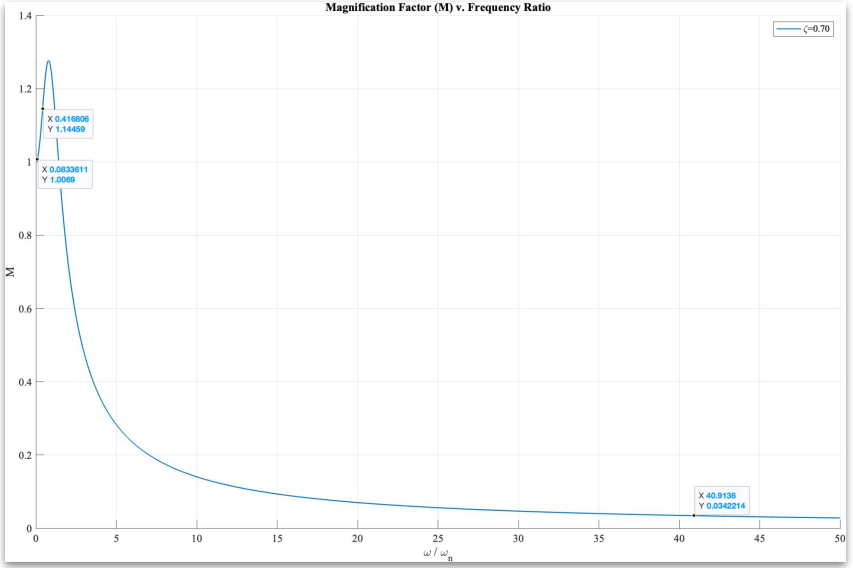

Figure 7. Expected displacement magnification factor of the system at various speeds corresponding to those tested on the previous slide.