Bouncing Balls

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Problem Posed

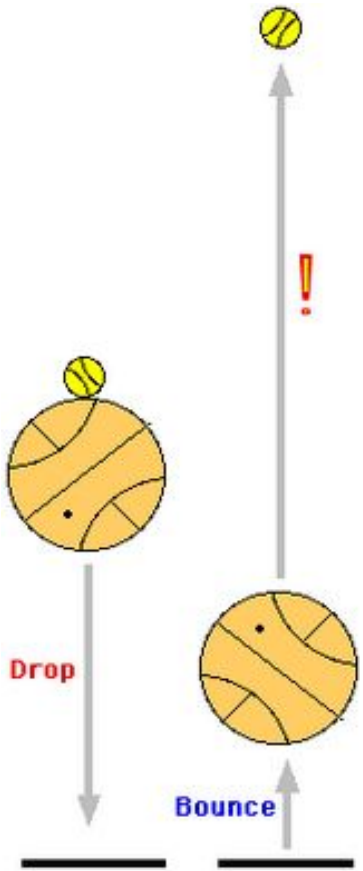


Figure: Double ball drop

The following assumptions were made for the system:

- No air resistance.
- The motion occurs in one dimension.

Rigid Body Collision Approach

We first assumed that the collision was between rigid bodies

We used the law of Conservation of Momentum:

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2 \tag{1}$$

And the Newtonian Restitution Law:

$$-e = \frac{v_2 - v_1}{u_2 - u_1} \tag{2}$$

Here m = mass, u = initial velocity, v = final velocity, e = coefficient of restitution, with 1 representing the tennis ball and 2 representing the basketball.

First Approach

- Collisions occur sequentially
- Basketball has reformed fully before collision with tennis ball
- We realised this approach was incorrect. This was confirmed by a high speed video.

Second Approach

- Collisions occur simultaneously
- The tennis ball collides with the basketball while it is compressed against the ground
- The basketball's reformation projects the tennis ball

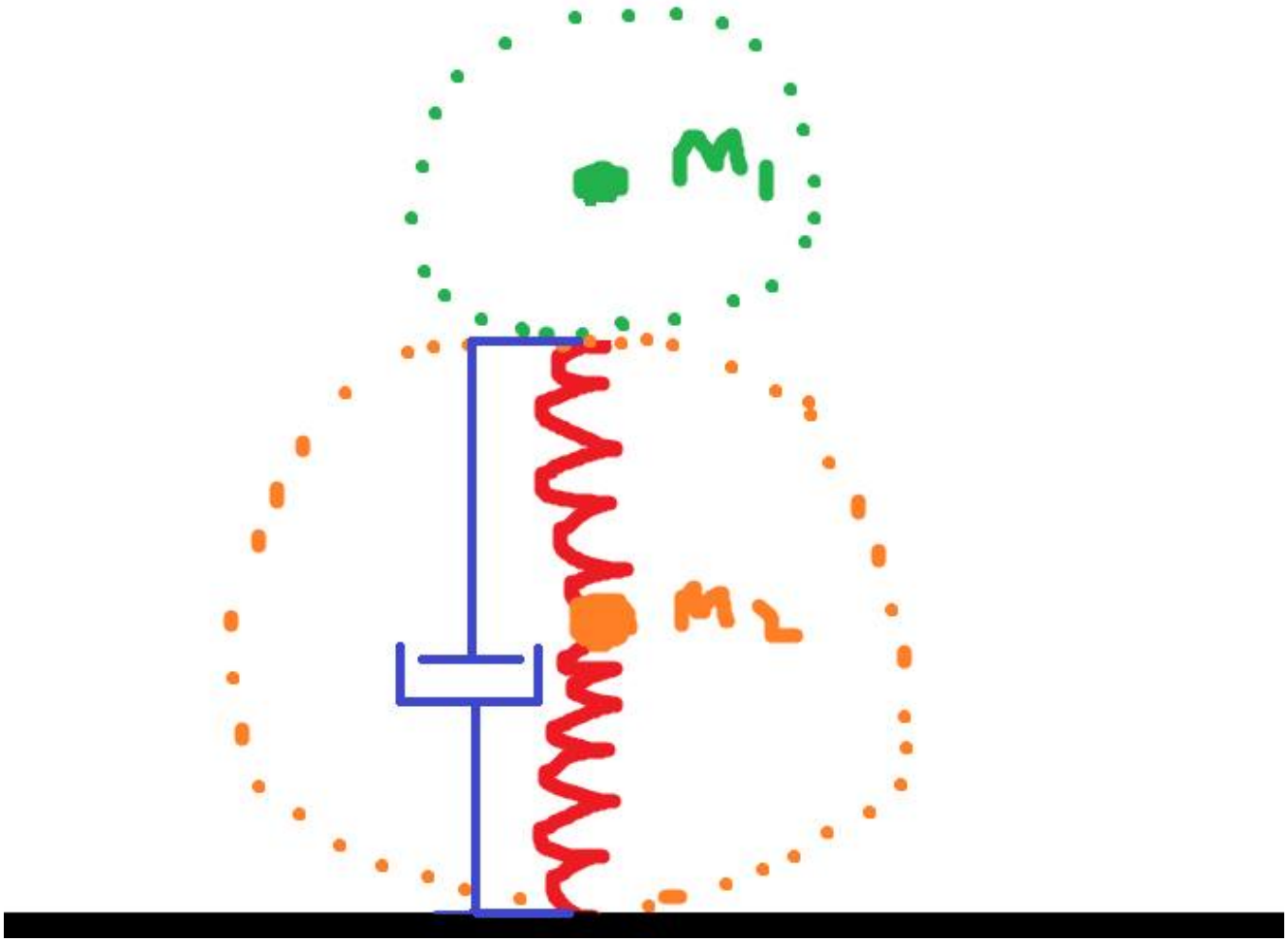
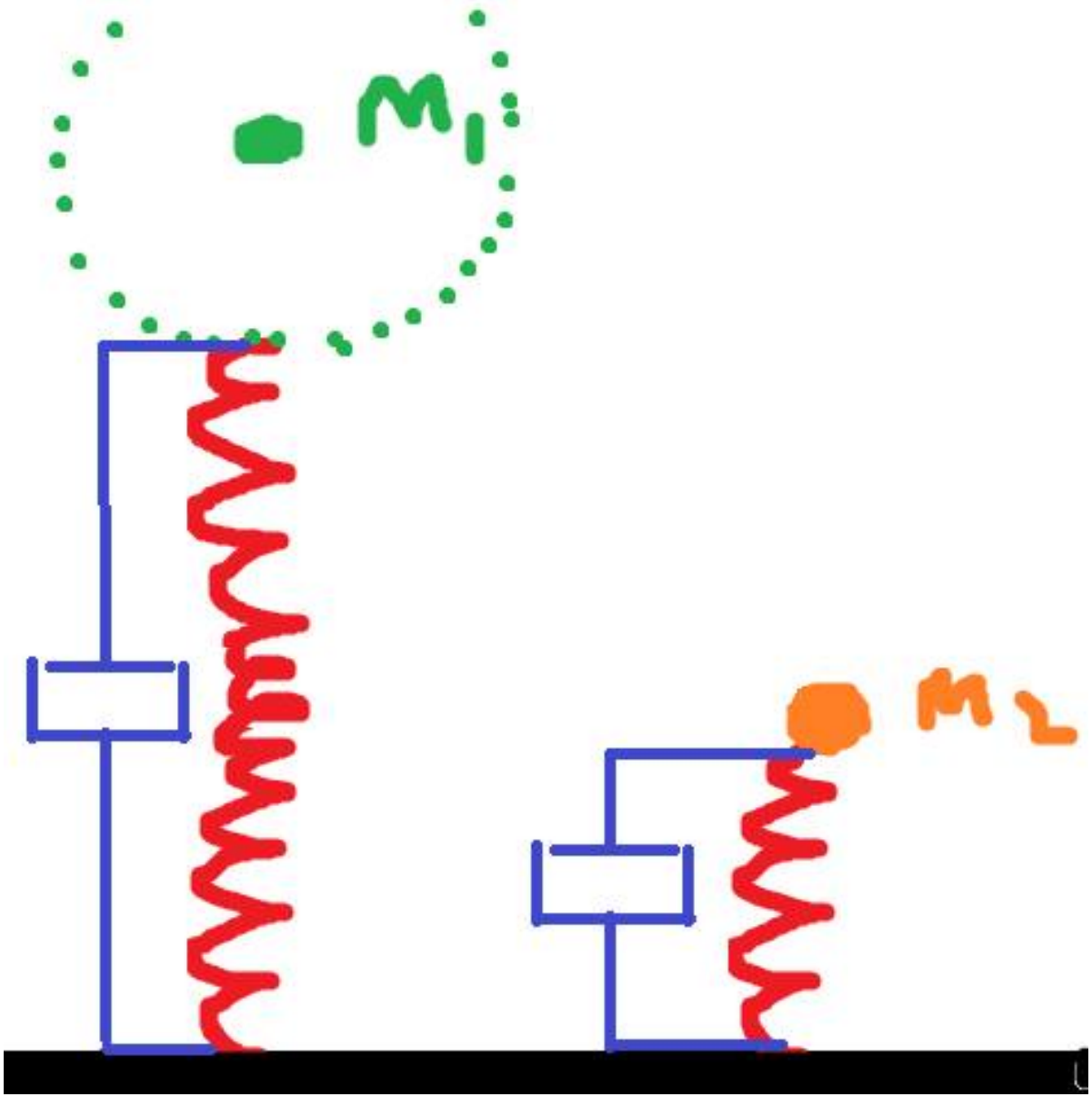


Figure: Balls impact simultaneously


M1
M2

The bouncing of the basketball was modelled as a damped spring, with the following equation:

$$m_2\ddot{x_2} + c_2\dot{x_2} + k_2x_2 = -m_2g \tag{3}$$

The collision between the two balls was modelled using the following equation:

$$m_1\ddot{x_1} = -m_1g \tag{4}$$

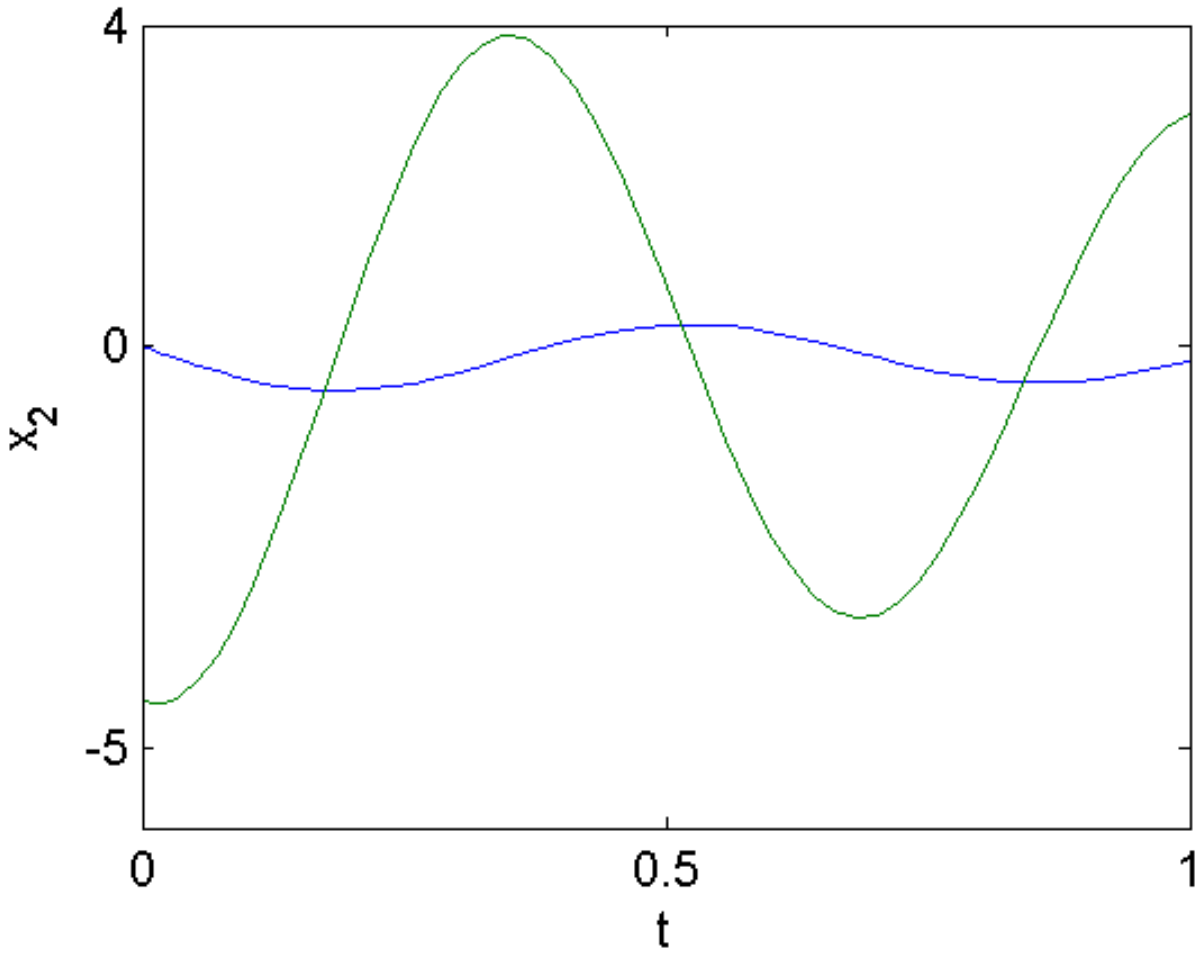


Figure: This plots the solution to equation 4

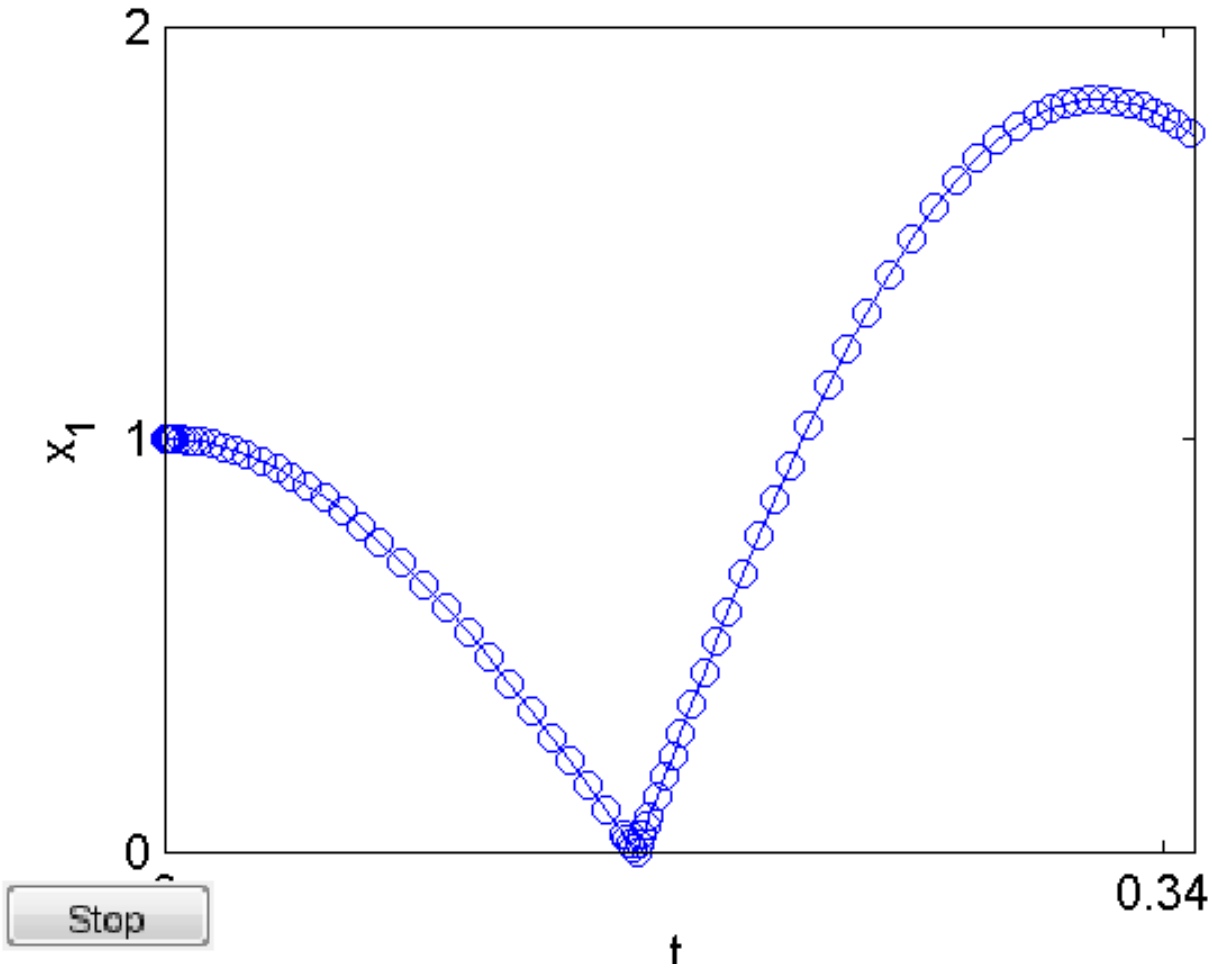


Figure: MatLab output of final model, plotting displacement against time

Summary

- We first used rigid body collisions, which was very inaccurate.
- We then tried a sequential spring approach, which didn't model the behaviour correctly.
- We settled on the simultaneous spring model.

With more time, we would model the tennis ball basketball collision as a spring damper system. This would give us more accurate results.

Any questions???