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Study on Effect of Spring and Damping Elements on UAV Landing Gear System

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DIALOG

ABSTRACT

As the world recovers from a global pandemic, the need for unmanned aerial vehicles (UAV) for delivery of medical as well as emergency critical supplies is more than ever. This research study aims for the development of a suitable damping mechanism in landing gear to ensure safety of sensitive payloads during the delivery. The damping mechanism consists of a spring damper system that protects the critical medical payload keeping the shock transmitted due to impact on landing well below 5g allowing us to perform delivery of the required number of supplies even in rough runways. We simplified the landing gear into a mass-spring-damper system and modelled it using MATLAB/Simulink for a given set of aircraft parameters. The model was first validated with reference case and sensitivity analysis of damping coefficient and spring constant to the shock transmitted was conducted. We finally obtained the relation between the required stiffness of the damping mechanism and the corresponding damping coefficient to keep the shock transmitted below 5g which could then be utilized for the choice of materials necessary in landing gear design.

Introduction

Medical supplies while delivery through UAV can be shock sensitive and their prevention from damage during takeoff and landing are of major concern. Thus designing a suitable shock-absorbing mechanism to resist such induced loadings possess a great importance. The scope of this study is to choose proper materials for spring and damping constants to limit the shock transmitted within 5g

Methodology

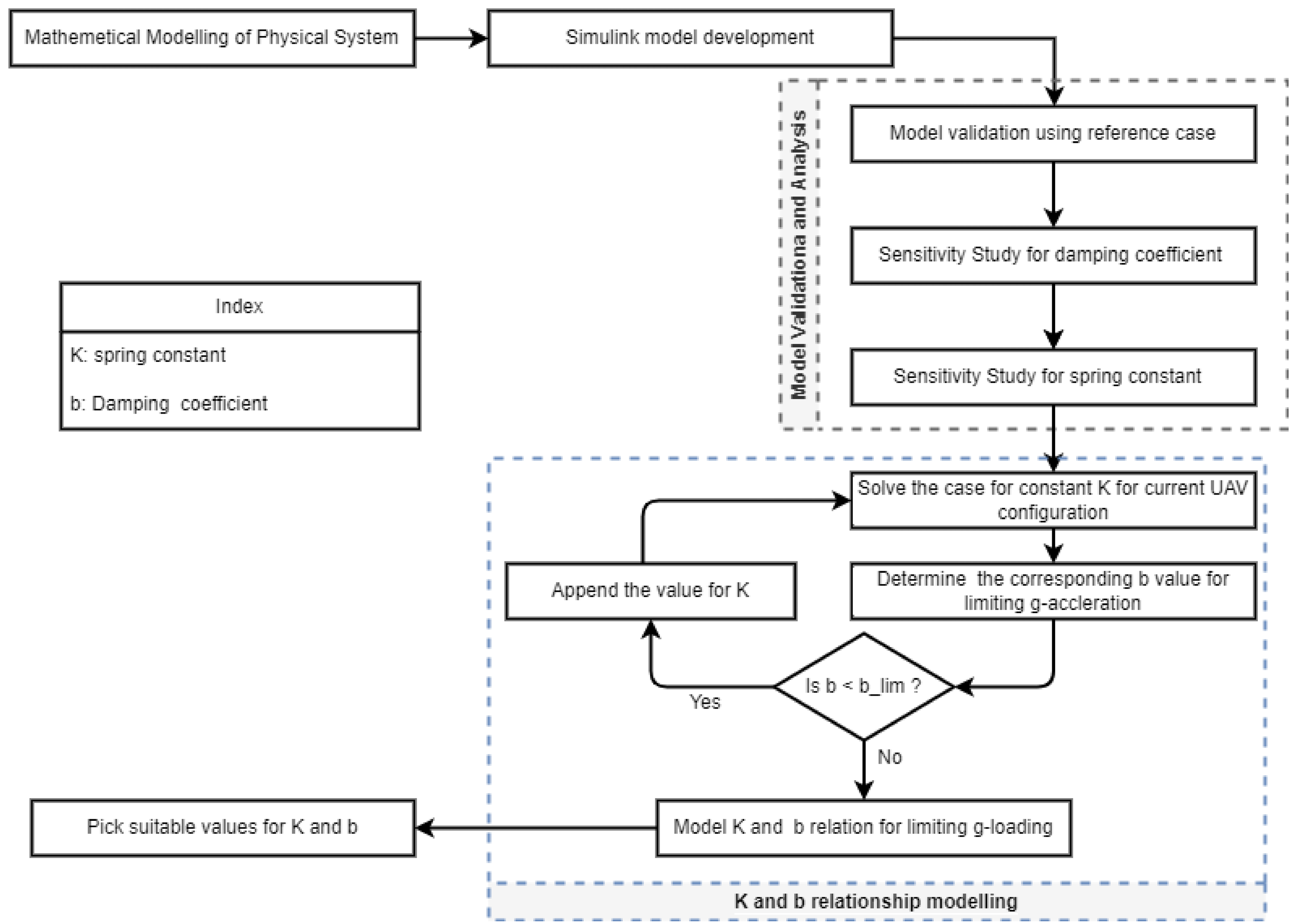
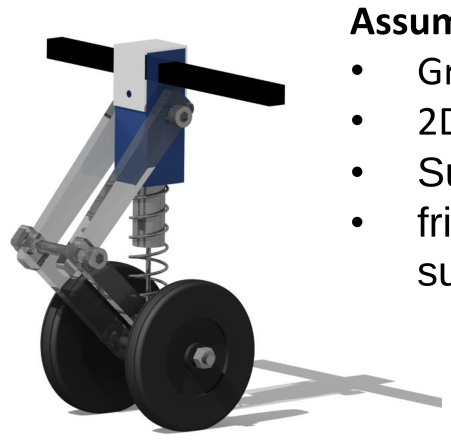


Figure 1: Methodology

Model Description

The dynamic equilibrium equations of the two masses shown in figure are;

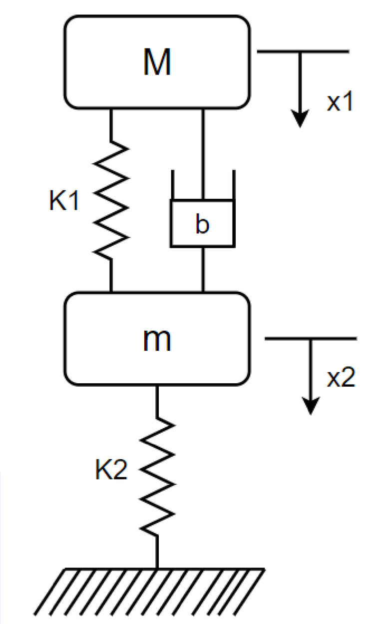


Assumptions:

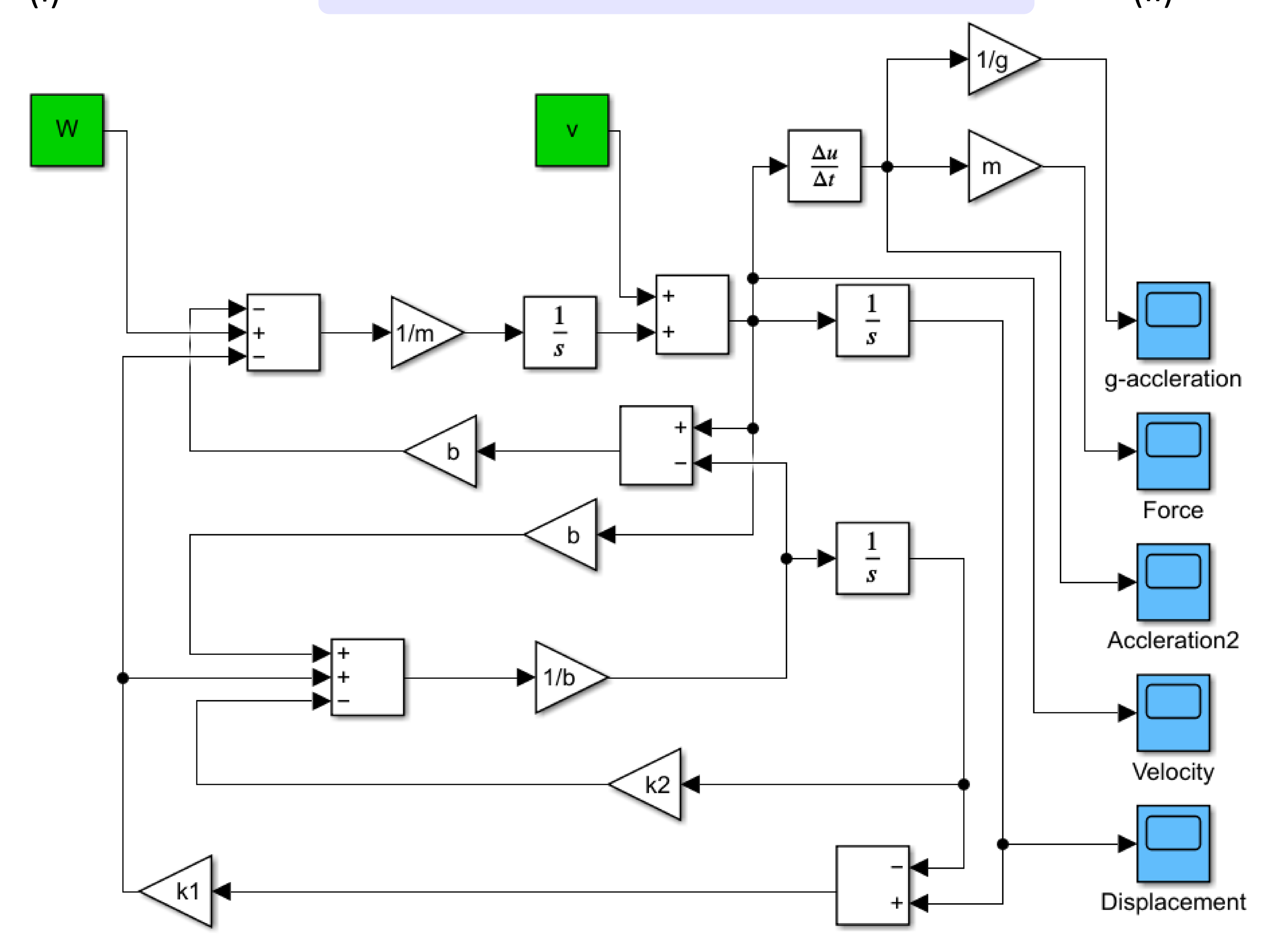
- Ground induced aerodynamic phenomena ignored,
- 2D model with constant dynamic coefficients,
- Suspension is modified with a linear damper;
- friction forces at the joints and on the road surfaces are not considered

$$M\ddot{x}_1 + k_1(x_1 - x_2) + b\,(\dot{x}_1 - \dot{x}_2) = F$$
$$m\ddot{x}_2 + k_1x_2 = k_1(x_1 - x_2) + b(\dot{x}_1 - \dot{x}_2)$$
$$considering, m \rightarrow 0\ (M > m)$$

(i)

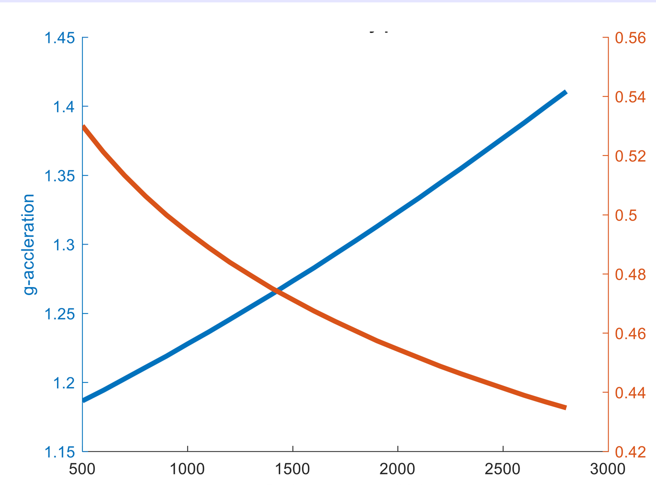


(ii)

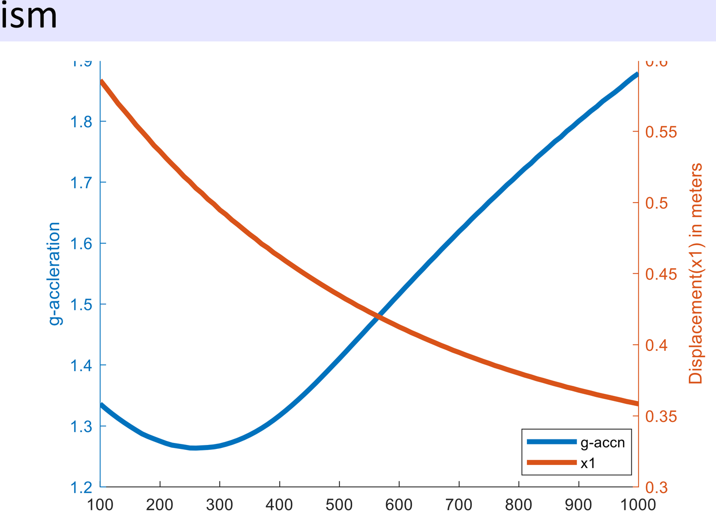


(ii)

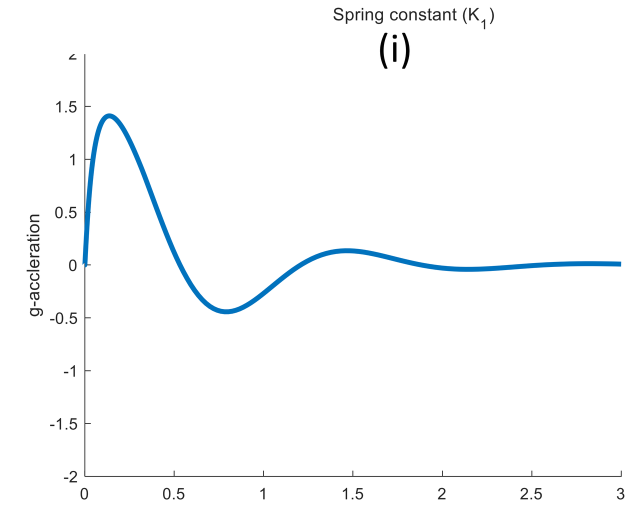
Figure 3: (i) Physical Model (ii) Mathematical model (iii) Simulink model of the landing gear mechanism



(i)



(ii)



(iii)

Figure 4: (i) K sensitivity (ii) b sensitivity (iii) Model damping validation

Total Weight	5kg
Load on Nose LG	1.16kg
Load on Main LG	1.92kg
Vertical Velocity	1.5 m/s
FOS	1.2

Table 1: Aircraft parameters

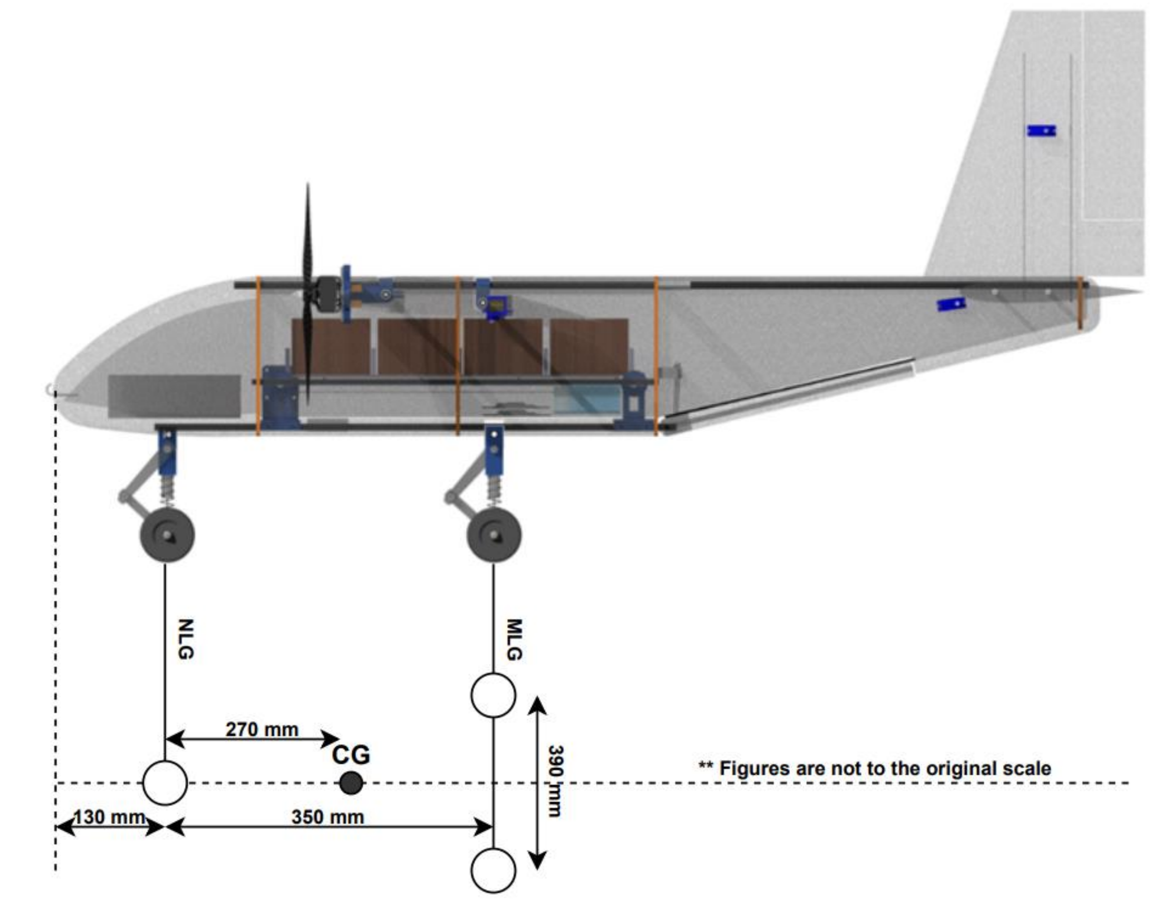


Figure 5: Landing gear configuration

Results

1. For a change of ±10% in damping coefficient(b), the change in transmitted shock in g was found to be 3.76 %.
2. For a change of ±10% in spring constant(K), the change in transmitted shock in g was found to be 2.29 %.

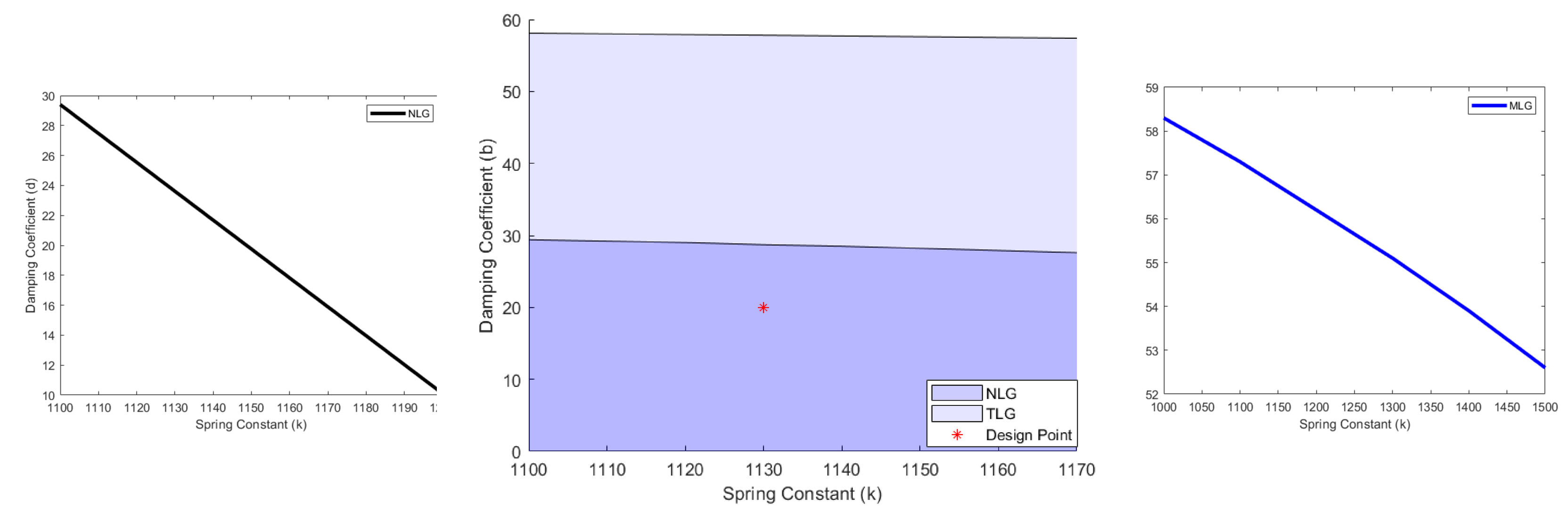


Figure 6: Damping Coefficient(b) vs Spring Constant(K)

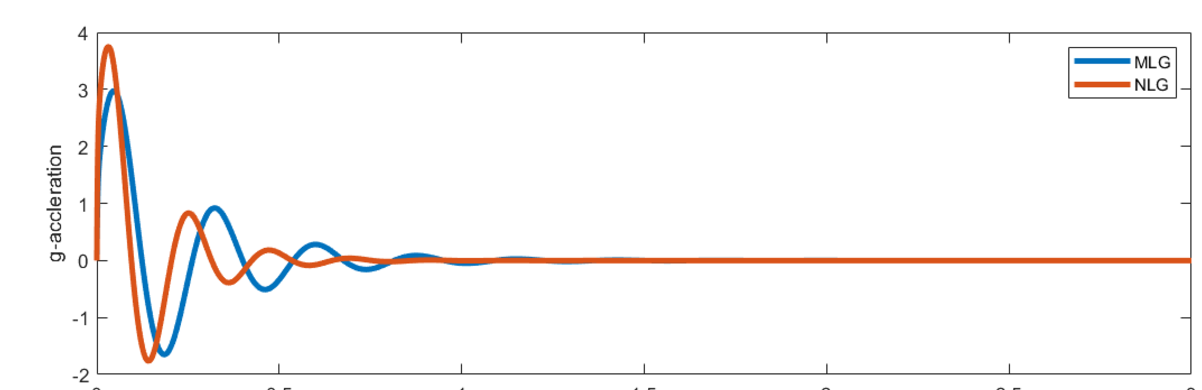


Figure 7: Transmitted shock(g) vs Time

Conclusion

1. Impact shock transmitted to the aircraft is heavily dependent on design parameters to be selected such as shock absorber damping coefficient (b), shock absorber spring constant (K1) and tire spring constant (K2).
2. We obtained the relation between the required stiffness of the damping mechanism and the corresponding damping coefficient to keep the shock transmitted below 5g which could then be utilized for the choice of materials necessary in landing gear design.