

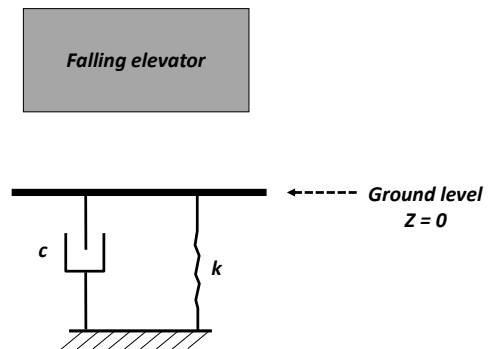
Homework # 2

NOTE: Please make sure to show and explain all the steps followed to arrive at the solution. Otherwise we are unable to assess your understanding of the material and give you credit for your answers.

1. **Laplace transforms:** Solve the following differential equation using the Laplace transform method:

$$a\ddot{x} + b\dot{x} = A\sin(\omega t), \quad x(0) = 1$$

2. **Falling elevator – safety design application:** An engineer is studying the effect of external accelerations on human health with particular focus on industrial accidents. As part of his research, he is evaluating different types of elevator safety systems. Specifically, consider a simple elevator of mass 1000 Kg, loaded with eight persons of total mass 500 Kg, that is free falling from a height of 5 meters (a little less than two floors) due to a broken cable. A spring-damper combination is located on the ground, which has a platform of *negligible mass* located at the ground level as indicated in the figure (the spring and damper are located inside a pit and allow the elevator to travel below the ground level). The spring force constant is $k = 7500$ N/m and the damper constant is 3000 N s/m. **For simplicity assume that the acceleration of gravity is equal to 10 m/s^2 .**



- Calculate the velocity of the elevator for the instant when it first contacts the platform.
- Draw the free body diagram and write the equation of motion of the elevator for the time it is in contact with the platform (assume that the elevator attaches to the platform as soon as it comes into contact with it, and assume that this happens at time = 0).
- Solve for the position of the elevator, $x(t)$, for time > 0 .
- Using the above solution, calculate the minimum depth required for the pit. That is, what is the maximum displacement of the platform in the negative direction? **[For simplicity you can solve this numerically by plotting $x(t)$ and finding the minimum]**
- Calculate the absolute value of the maximum acceleration that the persons inside the elevator are subjected to and express it in terms of ' g ' (the acceleration of gravity). That is, how many g 's will the persons in the elevator be subjected to? **[For simplicity you can calculate the acceleration as a function of time numerically by differentiating the position twice, and then you can look for its largest absolute value]**