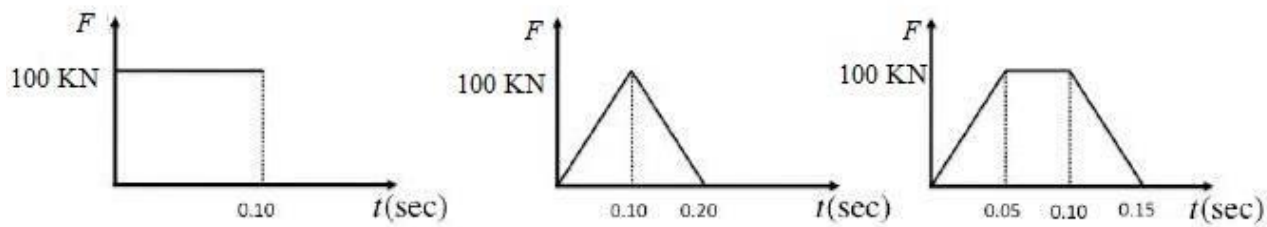
Matlab Sheet 2

Single Degree of Freedom - Free and Forced undamped system

1. We are interested in the natural frequency of a wing in bending. The wing tip is displaced and released, and a laser sensor mounted near the wing is used to measure the response under the initial displacement. The measured response frequency (or damped natural frequency) is 5.5 Hz and it takes 11 cycles to half amplitude.
   (a) If the wing is represented by a SDOF system with an equivalent set of mass, spring and damper, determine the viscous damping ratio for the wing. Is the wing lightly damped? Calculate the undamped natural frequency of the wing in bending.
   (b) The wing has been equipped with a fuel tank weighing 680 Kg at the wing tip, decreasing the response frequency to 5.0 Hz. Determine the equivalent empty wing mass and spring constant.

2. We are interested in the transient response of the above wing, under the following loading conditions.
   (a) A static load of 100 KN displaces the wing tip. Released from the load, the wing shows the decaying oscillation.
   (b) The impact load of 100 KN is applied over 0.001 seconds.
   (c) A step force, a triangle-shaped force is applied to the wing at rest as shown.
   (d) A trapezoid-shaped force is applied to the wing at rest as shown.



   (e) A sinusoidal force of 100 KN at 5.0, 5.5 and 10.0 Hz is applied ($F(t) = 100000 \sin\Omega t$).
   (f) The wing experiences loading and unloading in the mission profile. For an arbitrarily shaped loading, one can use the Fourier series such as

$$F(t) = 100 \left(\frac{4}{\pi}\cos\Omega t - \frac{4}{3\pi}\cos 3\Omega t + \frac{4}{5\pi}\cos 5\Omega t - \frac{4}{7\pi}\cos 7\Omega t + \ldots - \frac{4}{15\pi}\cos 15\Omega t\right)$$

   and $\Omega = 2\pi$ (5Hz). *Flow-induced loading is random in nature.
   Determine the transient response of the wing tip under the above loading conditions using the R-K method. Plot the response of the wing tip, normalized by the defined static displacement, from 0 to 4 seconds for the free response and from 0 to 10 seconds for the forced response.