Max Marks: 25   Time: 1 hr
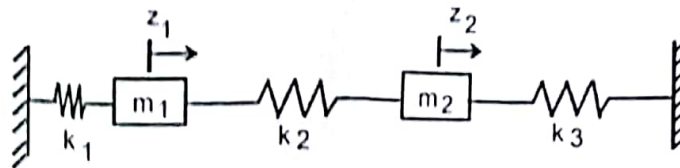
Q.1   In the two degrees of freedom system shown below (with $z_1 > z_2$), determine the natural frequencies and corresponding relative values of amplitudes. Assume $m_1 = 2$ N-s^2/m, $m_2 = 4$ N-s^2/m; and $k_1 = k_3 = 5$ N/m, $k_2 = 10$ N/m ?   (10)

Q.2   State **TRUE OR FALSE**. If 'FALSE', change the **wrong words or phrase** in the sentence and **REWRITE** the complete sentence correctly (**Do not change key** words or phrase in sentence marked in block letters while rewriting).   (3)

(a) For an **underdamped** system subjected to free vibrations, displacement amplitude and time period both decrease with the increase in number of cycles.

(b) **When frequency ratio r is large (r >> 1), force transmitted** to the foundation is small compared to inertial force (i.e., kA) **and the force transmissibility** is small.

(c) When a compression wave is reflected back from the free end, it will be reflected as a compression wave with double the particle velocity and twice the stress.

Q.3   State the reason in short (supplement your answers with formulae wherever applicable).   (4)

(a) For an underdamped system under forced vibrations, initially for a short while, the vibrations are not steady.

(b) A very high speed rotary machine can pass through the resonant frequency without causing intolerably high (i.e., close to infinity) displacement amplitude.

(c) The fundamental mode and first few modes of vibration are only important in geotechnical earthquake engineering.

(d) R-waves are non-dispersive but still their velocity changes with the frequency during geotechnical investigation.

Q.4   Give short answer to the following (supplement your answers with formulae wherever applicable).   (4)

(a) What is the unique value of damping ratio D for an acceleration pick-up ? Why?

(b) The general solution of free undamped vibration is $z = A \sin(\omega_n t + \alpha)$. What does phase difference α indicate in this expression ?

(c) Why are Rayleigh waves considered very important in geotechnical earthquake engineering ?

(d) Why do geotechnical engineers measure Rayleigh wave velocity for determination of dynamic soil properties in place of shear waves or compression waves ?

Q.5   A machine weighting 20 kN is mounted over a foundation block with a base of 5 m^2 and a weight of 30 kN. The coefficient of elastic uniform compression for the subsoil (for 5 m^2 area) and damping ratio are, respectively, 20000 kN/m^3 and 0.10. Determine the natural frequency (in cps), maximum amplitude (in mm) and the maximum force transmitted, if exciting force $F = 0.1\,\omega^2 \sin \omega t$ (in units of N).   (4)