AE31002 Structural Dynamics

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Discrete Systems and Spring

$$F_{s} \longleftarrow \begin{array}{c} x_{1} & k & \longrightarrow x_{2} \\ F_{s} \longleftarrow & & & & & \\ F_{s} = k(x_{2} - x_{1}) \end{array}$$

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Discrete Systems and Spring



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Discrete Systems and Spring



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Discrete Systems and Spring



Parallel Springs

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Parallel Springs



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Parallel Springs



$$F_{s1} = k_1(x_2 - x_1)$$
 and

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Parallel Springs



$$F_{s1} = k_1(x_2 - x_1)$$
 and $F_{s2} = k_2(x_2 - x_1)$

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Parallel Springs



$$F_{s1} = k_1(x_2 - x_1)$$
 and $F_{s2} = k_2(x_2 - x_1) \Rightarrow F_s = k_{eq}(x_2 - x_1)$

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Parallel Springs



 $F_{s1} = k_1(x_2 - x_1)$ and $F_{s2} = k_2(x_2 - x_1) \Rightarrow F_s = k_{eq}(x_2 - x_1)$ Where $k_{eq} = k_1 + k_2$;

Parallel Springs



 $F_{s1} = k_1(x_2 - x_1) \text{ and } F_{s2} = k_2(x_2 - x_1) \Rightarrow F_s = k_{eq}(x_2 - x_1)$ Where $k_{eq} = k_1 + k_2$;

Similarly for *n* number of parallel springs

$$k_{eq} = \sum_{i=1}^{n} k_i$$

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Springs in Series

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 $F_s = k_1(x_0 - x_1)$ and

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$$F_s = k_1(x_0 - x_1)$$
 and $F_s = k_2(x_2 - x_0)$

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$$F_s \longleftarrow X_1 \longrightarrow k_1 \longrightarrow k_2 \longrightarrow K_2$$

$$F_s = k_1(x_0 - x_1)$$
 and $F_s = k_2(x_2 - x_0) \Rightarrow F_s = k_{eq}(x_2 - x_1)$

$$F_s = k_1(x_0 - x_1) \text{ and } F_s = k_2(x_2 - x_0) \Rightarrow F_s = k_{eq}(x_2 - x_1)$$

Where $k_{eq} = \{\frac{1}{k_1} + \frac{1}{k_2}\}^{-1}$;

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$$F_{s} \longleftarrow x_{1} \qquad \stackrel{k_{1}}{\longrightarrow} \stackrel{x_{0}}{\longrightarrow} \stackrel{k_{2}}{\longrightarrow} \stackrel{k_{2}}{\longrightarrow} F_{s}$$

 $F_s = k_1(x_0 - x_1)$ and $F_s = k_2(x_2 - x_0) \Rightarrow F_s = k_{eq}(x_2 - x_1)$ Where $k_{eq} = \{\frac{1}{k_1} + \frac{1}{k_2}\}^{-1}$; Similarly for *n* number of springs in series

$$k_{eq} = \Big(\sum_{i=1}^n \frac{1}{k_i}\Big)^{-1}$$

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In the case of **static elastic deformation**, the internal **elastic forces**, try to restore the system to the position of equilibrium.

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In the case of **pendulum**, restoring force is force of **gravity** (Rigid body motion).

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In the case of **vibration**, D'Alembert reasoned that the **sum of the forces** acting on a particle result in acceleration \ddot{x} . The inertial force can be computed by multiplying the mass of the body, $F = m\ddot{x}$.

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In the case of **vibration**, D'Alembert reasoned that the **sum of the forces** acting on a particle result in acceleration \ddot{x} . The inertial force can be computed by multiplying the mass of the body, $F = m\ddot{x}$.

If the **force** so computed is applied to the body **at its mass center** in the direction **opposite to its acceleration**, the dynamic problem is reduced to one of statics. This is the D'Alembert principle.

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The number co-ordinates

DQC

Degrees of Freedom

The number co-ordinates



Degrees of Freedom

The number co-ordinates



DQC

Degrees of Freedom

The number co-ordinates



DQC

A SDOF System

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Degrees of Freedom

A SDOF System



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A SDOF System



Equilibrium equation $m\ddot{x} + c\dot{x} + kx = P(t)$, — Dynamic Equilibrium Equation.

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A SDOF System



Equilibrium equation $m\ddot{x} + c\dot{x} + kx = P(t)$, — Dynamic Equilibrium Equation. If p(t) = 0, it is free vibration.

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