Transcript for 4.5 Equivalent Point Load

0:01

Hello. In today's video lecture, we will be talking about the equivalent point load. The equivalent point load is a single point force that is statically equivalent to an original distributed force. In this example, the distributed force is shown, and the solid red arrow represents the equivalent point load. Both the distributed force and the equivalent point load cause the same acceleration and angular acceleration if the body is free, and the same reaction forces if the body is constrained.

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Why use the equivalent point load? Distributed forces are difficult to use directly in equilibrium equations because they require integrals in both force and moment equations, in addition to the usual complexity of equilibrium analysis. Because of this, we typically convert distributed forces into equivalent point loads before creating equilibrium equations or equations of motion.

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Finding the equivalent point load requires defining the magnitude, direction, and point of application. For now, we consider distributed forces with a uniform direction, so the direction remains unchanged. What varies is the magnitude and point of application. These can be determined using integration or the method of composite parts.

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As a lead-in to integration, consider a cantilever beam with three forces. To find a single statically equivalent force, we add the forces to find the magnitude. To find the location, we set the moment of the equivalent force equal to the sum of the moments of the original forces. This idea forms the basis of the integration method.

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To find the equivalent point load via integration, imagine the distributed force as an infinite number of small forces. The magnitude of the equivalent point load is the integral of the force function from x_min to x_max. The force function f(x) gives the magnitude of the distributed force at any x.

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To find the point of application, we use the moment integral: the integral of f(x) times x over the same limits. This moment must equal the moment of the equivalent point load. Solving for x_eq gives the location.

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For discontinuous force functions, we break the function into sections, integrate each separately, and add the results. The same applies to the moment integrals.

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For 2D surface forces, the force function depends on both x and y. The magnitude is the integral of the force function over the area. The point of application requires finding both x_eq and y_eq using moment integrals in each direction.

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For body force problems, the force function depends on x, y, and z. The magnitude is the triple integral of the force function, and the point of application requires x_eq, y_eq, and z_eq.

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The method of composite parts provides a geometry-based alternative to integration. The magnitude is the area under the force function, and the equivalent point load passes through the centroid of that area. For surface forces, the magnitude is the volume under the force function, and the equivalent point load passes through the centroid of the volume.

13:29

This concludes the video lecture. Thank you for watching.