

$$ax^2 + bx + c = 0.$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$2\pi \text{ rad} = 360^\circ =$$

$$\frac{\sin \theta}{\sin \theta} = \frac{\sin \theta b}{b} = \frac{\sin \theta c}{c}$$

$$a^2 + c^2 = a^2 + b^2 + 2ab \cos \theta c$$

$$c = \pi (180^\circ)$$

$$\sin \theta = \frac{b}{c} = \frac{\text{Opposite}}{\text{Hypotenuse}}$$

$$\cos \theta = \frac{a}{c} = \frac{\text{Adjacent}}{\text{Hypotenuse}}$$

$$\tan \theta = \frac{b}{a} = \frac{\text{Opposite}}{\text{Adjacent}}$$

$$\sin(\alpha \pm \beta) = \sin \alpha \cos \beta \pm \cos \alpha \sin \beta$$

$$\cos(\alpha \pm \beta) = \cos \alpha \cos \beta \mp \sin \alpha \sin \beta$$

$$g = 32.2 \text{ ft/sec}^2 = 9.81 \text{ m/sec}^2$$

$$N = \frac{\text{kg} \cdot \text{m}}{\text{sec}^2} \quad \text{slug} = \frac{\text{lb}}{(\text{ft/sec}^2)}$$

Units for moment of a force	
U.S. Customary	SI
ft.-lb. or in.-lb.	N-m

Chapter 2: Force Vectors

$$R = \sum F_i, \quad F_i = F \hat{\lambda}_i$$

$$\hat{\lambda}_{AB} = \frac{dr_{AB}}{|dr_{AB}|} = \frac{\Delta x \hat{i} + \Delta y \hat{j} + \Delta z \hat{k}}{\sqrt{(\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2}}$$

$$\hat{\lambda}_{AB} = \cos \theta_x \hat{i} + \cos \theta_y \hat{j} + \cos \theta_z \hat{k}$$

$$\hat{\lambda}_{AB} = \sin \theta \cos \phi \hat{i} + \sin \theta \sin \phi \hat{j}$$

$$\hat{\lambda} = \cos^2 \theta_x + \cos^2 \theta_y + \cos^2 \theta_z = 1$$

$$F_D = F_x \hat{i} + F_y \hat{j} = F \cos \theta \hat{i} + F \sin \theta \hat{j} = F \Delta \theta$$

Chapter 3: Equilibrium of Particles

$$\sum F_D = 0 \Rightarrow \sum F_x \hat{i} + \sum F_y \hat{j} + \sum F_z \hat{k} = 0$$

$$\hat{i}: \sum F_x = 0$$

$$\hat{j}: \sum F_y = 0$$

$$\hat{k}: \sum F_z = 0$$

Chapter 4: Moments of a Force

The moment of F_D about point A

$$M_{DA} = r_{DA} \times F_D, \quad |M_{DA}| = r_{DA} \perp F_D$$

where r_{DA} is a position vector from point on the line of action of F_D

$$M_A = (Fr) \sin \phi = F(\sin \phi) r = F d_{\perp}$$

$$M_A = (Fr) \sin \phi = \left(\frac{r}{F} \right) \phi = r \perp F$$

$$M_{DA} = \sum r_i \times F_i = \sum r_i \times F_i = -\sum r_i \times F_i = \sum F_i \times r_i$$

Moment about a line:

$$M_{AB} = \hat{\lambda}_{AB} \cdot \sum r_i \times F_i = \hat{\lambda}_{AB} \cdot (M_D)$$

$$M_{AB} = \begin{bmatrix} \lambda_y & \lambda_z \\ \Delta x & \Delta y \end{bmatrix} \begin{bmatrix} F_x & F_y & F_z \\ F_x & F_y & F_z \end{bmatrix}$$

Equivalent Force-Couple System:

$$R_D = \sum F_D$$

$$M_{DO} = \sum M_{DO}$$

$$= \sum (r_i \times F_i) + \sum M_{i \text{ couples}}$$

Equivalent Systems:

$$\sum F_{D \text{ system}} = \sum F_{D \text{ system}}$$

$$\sum M_{DO \text{ system}} = \sum M_{DO \text{ system}}$$

Chapter 5: Equilibrium of Rigid Bodies

$$\sum F_D = 0, \text{ and } \sum M_{DO} = 0$$

$$\hat{i}: \sum F_x = 0$$

$$\hat{j}: \sum F_y = 0$$

$$\hat{k}: \sum F_z = 0$$

$$\hat{i}: \sum M_x = 0$$

$$\hat{j}: \sum M_y = 0$$

$$\hat{k}: \sum M_z = 0$$

2D Planar:

$$\rightarrow \sum F_x = 0$$

$$\uparrow \sum F_y = 0$$

$$\curvearrowright \sum M_P = 0$$

Reaction forces prevent translation;
Reaction moments prevent rotation

Chapter 7: Internal Forces and Moments

In two-dimensions:

- N = Normal Axial Force
- V = Transverse Shear Force
- M = Bending Moment

$$\frac{dV}{dx} = -w, \quad \frac{dM}{dx} = V$$

$$\frac{d^2 M}{dx^2} = -w(x)$$

Concentrated force P, shear discontinuity (jump):

$$V^+ - V^- = -P$$

Concentrated couple MC, moment jump:

$$M^+ - M^- = -MC$$

In three-dimensions:

- Nx = Axial Force
- Vy = Shear Force in y-direction
- Vz = Shear Force in z-direction
- Tx = Torque about the x-axis
- My = Moment about the y-axis
- Mz = Moment about the z-axis

Distributed loads

$$F = \int_L w(x) dx$$

$$F x^* = M = \int_L x w(x) dx$$

Effect of $w(x)$ is statically equivalent to resultant F at position x^* .

Chapter 8: Friction

$$F_f \leq (F_f)_{\text{max static}} = \mu_s FN$$

If at the max limit, on the verge of sliding and impending motion.

$$F_f = \mu_s FN$$

$$\text{Belt Friction: } \frac{T}{2} = e \mu \beta$$

Spring Forces and Torques

$$F_s = k_L(L^* - L)^1$$

$$M_s = k_B(\theta - \theta^*)$$

Chapter 11: Virtual Work

$$\delta U = \delta D + \delta W + \delta Q + \delta M = 0$$

Virtual Power:

$$\delta V = \delta D + \delta W + \delta M = 0$$

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Table of Contents Cee 101 Statics And Dynamics Purdue Engineering

1. Understanding the eBook Cee 101 Statics And Dynamics Purdue Engineering
 - The Rise of Digital Reading Cee 101 Statics And Dynamics Purdue Engineering
 - Advantages of eBooks Over Traditional Books
2. Identifying Cee 101 Statics And Dynamics Purdue Engineering
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Cee 101 Statics And Dynamics Purdue Engineering
 - User-Friendly Interface
4. Exploring eBook Recommendations from Cee 101 Statics And Dynamics Purdue Engineering
 - Personalized Recommendations
 - Cee 101 Statics And Dynamics Purdue Engineering User Reviews and Ratings
 - Cee 101 Statics And Dynamics Purdue Engineering and Bestseller Lists

5. Accessing Cee 101 Statics And Dynamics Purdue Engineering Free and Paid eBooks
 - Cee 101 Statics And Dynamics Purdue Engineering Public Domain eBooks
 - Cee 101 Statics And Dynamics Purdue Engineering eBook Subscription Services
 - Cee 101 Statics And Dynamics Purdue Engineering Budget-Friendly Options
6. Navigating Cee 101 Statics And Dynamics Purdue Engineering eBook Formats
 - ePub, PDF, MOBI, and More
 - Cee 101 Statics And Dynamics Purdue Engineering Compatibility with Devices
 - Cee 101 Statics And Dynamics Purdue Engineering Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Cee 101 Statics And Dynamics Purdue Engineering
 - Highlighting and Note-Taking Cee 101 Statics And Dynamics Purdue Engineering
 - Interactive Elements Cee 101 Statics And Dynamics Purdue Engineering
8. Staying Engaged with Cee 101 Statics And Dynamics Purdue Engineering
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Cee 101 Statics And Dynamics Purdue Engineering
9. Balancing eBooks and Physical Books Cee 101 Statics And Dynamics Purdue Engineering
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Cee 101 Statics And Dynamics Purdue Engineering
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Cee 101 Statics And Dynamics Purdue Engineering
 - Setting Reading Goals Cee 101 Statics And Dynamics Purdue Engineering
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Cee 101 Statics And Dynamics Purdue Engineering
 - Fact-Checking eBook Content of Cee 101 Statics And Dynamics Purdue Engineering
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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