



Fig. 1-16

- 1.94 In Fig. 1-17a, oil of viscosity  $\mu$  fills the small gap of thickness  $Y$ . Determine an expression for the torque  $T$  required to rotate the truncated cone at constant speed  $\omega$ . Neglect fluid stress exerted on the circular bottom.

▮ See Fig. 1-17b.  $\tau = \mu (dv/dy)$ ,  $v = r\omega = (y \tan \alpha)(\omega)$ ,  $dv/dy = (y \tan \alpha)(\omega)/Y$ .

$$\tau = \mu \left[ \frac{(y \tan \alpha)(\omega)}{Y} \right] = \frac{\mu y \omega \tan \alpha}{Y}$$

$$dA = 2\pi r \, ds = 2\pi(y \tan \alpha)(dy/\cos \alpha) = 2\pi y (\tan \alpha / \cos \alpha)(dy)$$

$$dF = \tau \, dA = \left( \frac{\mu y \omega \tan \alpha}{Y} \right) \left[ 2\pi y \left( \frac{\tan \alpha}{\cos \alpha} \right) (dy) \right] = \left( \frac{2\pi \mu \omega \tan^2 \alpha}{Y \cos \alpha} \right) y^2 \, dy$$

$$dT = r \, dF = (y \tan \alpha) \left( \frac{2\pi \mu \omega \tan^2 \alpha}{Y \cos \alpha} \right) y^2 \, dy = \left( \frac{2\pi \mu \omega \tan^3 \alpha}{Y \cos \alpha} \right) y^3 \, dy$$

$$T = \int_a^{a+b} \left( \frac{2\pi \mu \omega \tan^3 \alpha}{Y \cos \alpha} \right) y^3 \, dy = \left( \frac{2\pi \mu \omega \tan^3 \alpha}{Y \cos \alpha} \right) \left[ \frac{y^4}{4} \right]_a^{a+b} = \left( \frac{2\pi \mu \omega \tan^3 \alpha}{Y \cos \alpha} \right) \left[ \frac{(a+b)^4}{4} - \frac{a^4}{4} \right]$$

$$= \left( \frac{\pi \mu \omega \tan^3 \alpha}{2Y \cos \alpha} \right) [(a+b)^4 - a^4]$$

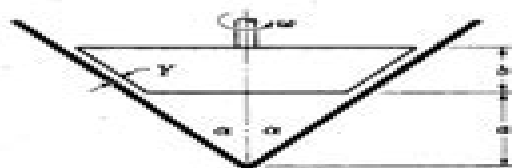


Fig. 1-17(a)

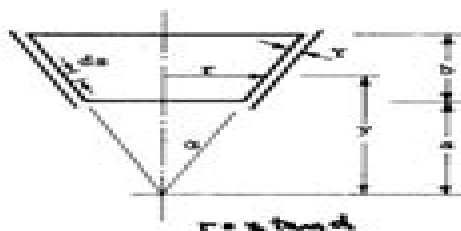
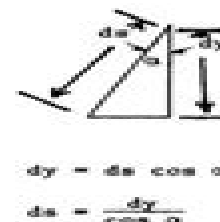


Fig. 1-17(b)



$$dy = ds \cos \alpha$$

$$ds = \frac{dy}{\cos \alpha}$$

- 1.95 A Newtonian fluid fills the gap between a shaft and a concentric sleeve. When a force of 788 N is applied to the sleeve parallel to the shaft, the sleeve attains a speed of 2 m/s. If a 1400-N force is applied, what speed will the sleeve attain? The temperature of the sleeve remains constant.

▮  $\tau = F/A = \mu (dv/dx)$ ;  $F/dv = \mu A/dx = \text{constant}$ . Therefore,  $F_1/dv_1 = F_2/dv_2$ ,  $\frac{788}{2} = 1400/dv_2$ ,  $dv_2 = 3.55 \text{ m/s}$ .

- 1.96 A plate separated by 0.5 mm from a fixed plate moves at 0.50 m/s under a force per unit area of 4.0 N/m<sup>2</sup>. Determine the viscosity of the fluid between the plates.

▮  $\tau = \mu (dv/dx)$   $4.0 = \mu[0.50/(0.0005)]$   $\mu = 0.00400 \text{ N} \cdot \text{s}/\text{m}^2 = 4.00 \text{ mPa} \cdot \text{s}$

- 1.97 Determine the viscosity of fluid between shaft and sleeve in Fig. 1-18.

▮  $\tau = F/A = \mu (dv/dx)$   $25/[(\pi)(\frac{1}{8})(\frac{1}{8})] = \mu[0.5/(0.004/12)]$   $\mu = 0.0212 \text{ lb} \cdot \text{s}/\text{ft}^2$



Fig. 1-18

# Fluid Mechanics Hydraulics Solved Problems

**Amithirigala Widhanelage  
Jayawardena**



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## **Table of Contents Fluid Mechanics Hydraulics Solved Problems**

1. Understanding the eBook Fluid Mechanics Hydraulics Solved Problems
  - The Rise of Digital Reading Fluid Mechanics Hydraulics Solved Problems
  - Advantages of eBooks Over Traditional Books
2. Identifying Fluid Mechanics Hydraulics Solved Problems
  - 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 Fluid Mechanics Hydraulics Solved Problems
  - User-Friendly Interface
4. Exploring eBook Recommendations from Fluid Mechanics Hydraulics Solved Problems
  - Personalized Recommendations
  - Fluid Mechanics Hydraulics Solved Problems User Reviews and Ratings
  - Fluid Mechanics Hydraulics Solved Problems and Bestseller Lists

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