

## Problem 2.47

[Difficulty: 2]

**2.47** Tape is to be coated on both sides with glue by drawing it through a narrow gap. The tape is 0.015 in. thick and 1.00 in. wide. It is centered in the gap with a clearance of 0.012 in. on each side. The glue, of viscosity  $\mu = 0.02 \text{ slug}/(\text{ft} \cdot \text{s})$ , completely fills the space between the tape and gap. If the tape can withstand a maximum tensile force of 25 lbf, determine the maximum gap region through which it can be pulled at a speed of 3 ft/s.

**Given:** Data on tape mechanism

**Find:** Maximum gap region that can be pulled without breaking tape

**Solution:**

Basic equation  $\tau_{yx} = \mu \cdot \frac{du}{dy}$  and  $F = \tau_{yx} \cdot A$

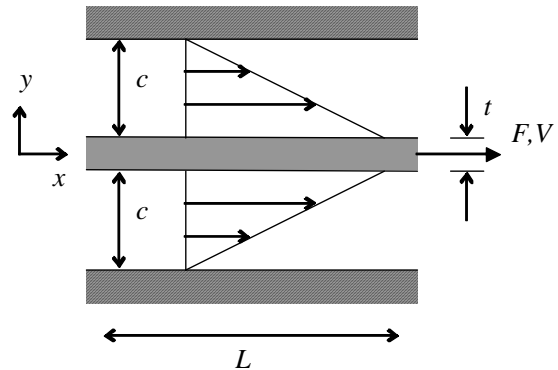
Here  $F$  is the force on each side of the tape; the total force is then  $F_T = 2 \cdot F = 2 \cdot \tau_{yx} \cdot A$

The velocity gradient is linear as shown  $\frac{du}{dy} = \frac{V - 0}{c} = \frac{V}{c}$

The area of contact is  $A = w \cdot L$

Combining these results  $F_T = 2 \cdot \mu \cdot \frac{V}{c} \cdot w \cdot L$

Solving for  $L$   $L = \frac{F_T \cdot c}{2 \cdot \mu \cdot V \cdot w}$



The given data is  $F_T = 25 \cdot \text{lbf}$   $c = 0.012 \cdot \text{in}$   $\mu = 0.02 \cdot \frac{\text{slug}}{\text{ft} \cdot \text{s}}$   $V = 3 \cdot \frac{\text{ft}}{\text{s}}$   $w = 1 \cdot \text{in}$

Hence  $L = 25 \cdot \text{lbf} \times 0.012 \cdot \text{in} \times \frac{1 \cdot \text{ft}}{12 \cdot \text{in}} \times \frac{1}{2} \times \frac{1}{0.02} \cdot \frac{\text{ft} \cdot \text{s}}{\text{slug}} \times \frac{1 \cdot \text{s}}{3 \cdot \text{ft}} \times \frac{1}{1} \frac{1}{\text{in}} \times \frac{12 \cdot \text{in}}{1 \cdot \text{ft}} \times \frac{\text{slug} \cdot \text{ft}}{\text{s}^2 \cdot \text{lbf}}$   $L = 2.5 \cdot \text{ft}$