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1) Capacity of Goblet

$$\pi \int_{13.305}^{19.140} ((1.3 \ln(x-13.2) - .4x + 8.25))^2 dx \approx 156.535$$

a) Volume of Glass Used

$$\pi \int_{2.02}^{2.615} \left(\frac{1}{100}x + 5\right)^2 dx - \pi \int_{2.091}^{2.615} (2 \ln(x-2) + 6)^2 dx - \pi \int_{2.02}^{2.615} (-50.202(x-2.615))^2 dx +$$

$$\pi \int_{2.091}^{2.615} (.755 \sin(x-2.5) + 1.5)^2 dx + \pi \int_{7.970}^{8.893} (1.5x - 11)^2 dx + \pi \int_{13.305}^{10.235} \left(\frac{1}{100}x + 2.25\right)^2 dx -$$

$$\pi \int_{9.279}^{12.606} (1.5x - 13)^2 dx + \pi \int_{9.279}^{12.606} \left(\frac{1}{100}x + .918\right)^2 dx + \pi \int_{12.606}^{13.305} ((1.3 \ln(x-12.5) - .4x + 9))^2 dx +$$

$$\pi \int_{13.305}^{19.140} ((1.3 \ln(x-12.5) - .4x + 9 - (1.3 \ln(x-13.2) - .4x + 8.25))^2 dx +$$

$$\pi \int_{19.140}^{19.599} ((1.3 \ln(x-12.5) - .4x + 9 - ((x-18.5)^2 + 2.5))^2 dx \approx 147.915$$

3) Center of Mass

$$\pi \int_a^b x f(x)^2 dx \text{ for all of the above equations} \approx 1237.410$$

Divide by volume: $1237.410 \div 147.915 \approx 8.366$

Radius of Base = $\frac{1}{100}(2.02) + 5 = 5.0202$

Ratio = $8.366 \div 5.0202 \approx 1.666$ which is < 3 .

4) thickness at thinnest point.

thinnest point occurs on graph of $.75\sin(x-2.5)+1.5$

$$\frac{d}{dx}(.75\sin(x-2.5)+1.5) = 375(\sin(x-2.499) - \sin(x-2.501))$$

$$0 = 375(\sin(x-2.499) - \sin(x-2.501))$$

$$x = -87.5$$

sub x into orig equation

$$y = .75$$

$$\frac{d}{dx}(0.75\sin(x-2.5)+1.5) = 0.75\cos(x-2.5)$$

$$0.75\cos(x-2.5) = 0 \quad \text{for } x > 2.091 \text{ \& } x < 7.970$$

$$\text{so } x = 4.0708 \text{ \& }$$

$$x = 7.21239$$

Using second derivative test:

4.0708 is a max and 7.212 is a min.

\therefore Min occurs at $x = 7.21239$

$$\text{and is } 0.75\sin(7.21239, -2.5) + 1.5 = 0.75$$

Correct answer - not quite sure how you get it.