Name :_____ **Quiz: No. 1** **Time: 15 minutes**

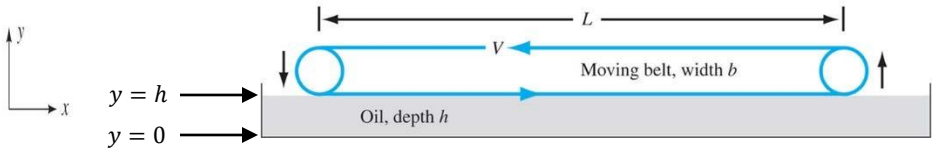
Student ID# : _____ **Course: ME 5160, Fall 2025**

The exam is closed book and closed notes.

The belt in the Figure below moves at steady velocity V and skims the top of a tank of oil of viscosity μ. Neglect air drag. If the velocity profile is:

$$u(y) = 1.1547V \sin\left(\frac{\pi y}{3h}\right)$$

and the belt moves at 2.5 m/s over SAE 30W oil at 20°C (μ = 0.29 kg/m-s) with L = 2 m, b = 60 cm, and h = 3 cm, what is the required belt-drive power P in Watts?



Equation: $\tau = \mu \frac{du}{dy}$

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Solution

KNOWN: $u(y), V, h, L, b$
FIND: P
ASSUMPTIONS: Incompressible and isotropic Newtonian fluid
ANALYSIS:

(a)
The shear stress on the belt can be expressed as:

$$\tau_{belt} = \mu \frac{du}{dy}\Big|_{y=h} = \mu \left[1.1547V \frac{\pi}{3h}\cos\left(\frac{\pi y}{3h}\right)\right]_{y=h} = 1.1547\mu V \frac{\pi}{3h}\cos\left(\frac{\pi}{3}\right) = 14.60\ N/m^2$$

+3 +2 +1

(b)

The force on the belt is given by:

$$F_{belt} = \tau_{belt} A_{belt} = \tau_{belt}(bL) = 1.1547\mu V \frac{\pi bl}{3h}\cos\left(\frac{\pi}{3}\right) = 17.52\ N$$

+1.5 +1 +0.5

(c)

Finally, the power is equal to:

$$P = F_{belt} V = 1.1547\mu V^2 \frac{\pi bl}{3h}\cos\left(\frac{\pi}{3}\right) = 43.8W$$

+0.5 +0.5