

Name : _____

Quiz: No. 1

Time: 15 minutes

Student ID# : _____

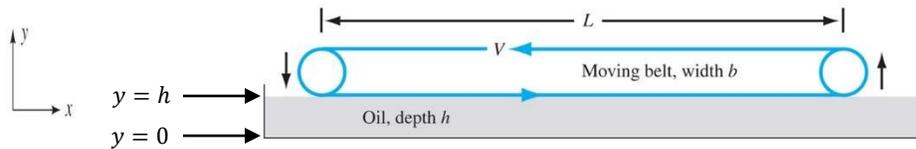
Course: ME 5160, Fall 2023

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 ($\mu = 0.29$ 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:

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

(b)

The force on the belt is given by:

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

(c)

Finally, the power is equal to:

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