An electric motor uses a flat belt to drive a fan as shown below.

Coefficient of friction is 0.35

Motor rotates at 880 rpm

Belt weighs 0.035 lb/in², is 10 in wide and 5/16 in thick.

Maximum allowable belt tension is 1,090 lbs

Angle of wrap for motor pulley is 141°

Angle of wrap for fan pulley is 210°

1. Determine the tensions in the belt.

\[
F_t = F_c (ALLOWABLE)
\]

\[
\frac{F_t - F_c}{F_c} = e^\frac{D_2}{D_1} \left( 1 + \left( \frac{D_2}{D_1} \right)^{\frac{1}{2}} \right)
\]

\[
\frac{1090 - 118}{118} = 2.37
\]

\[
F_t = 528 \text{ lb}
\]

\[
F_c = 118 \text{ lb}
\]

2. Determine the torque capacity of the motor pulley.

\[
T = (F_t - F_c) \times 7 = 893 \text{ in-lb}
\]
MD7. A band brake with a 200 degree angle of wrap has a 25 cm diameter drum. The coefficient of friction is 0.3.

\[
\frac{F_1}{F_2} = \cos \theta = \cos 0.3 \left( \frac{200}{180} \right) = 2.84 \quad \implies \quad F_1 = 2.84 F_2
\]

\[T = \mu (F_1 - F_2) \quad \Rightarrow \quad 350 = 0.25 \left( \frac{F_1 - F_2}{2} \right) \]

\[2.84F_2 - F_2 = 2800 \quad \Rightarrow \quad F_2 = 1522 N \]

\[F_1 = 2.84(1522) \quad \Rightarrow \quad F_1 = 4322 N\]

1. Determine the tensions in the band that would produce 350 N-m of braking torque.

2. Determine the band width given that the brake lining pressure is limited to 400 kPa.

\[\mu = \frac{400000}{m} = \frac{4322}{0.125} \quad \Rightarrow \quad W = 0.086 (m) \quad \Rightarrow \quad W = 8.6 \text{ (cm)}\]

3. Determine the brake lever arm length c given that the brake lever arms are a=7.5 cm, b=2.5 cm and the maximum allowed force is 100 N.

\[F_c = a F_2 - b F_1 \]

\[100 c = 7.5(1522) - 2.5(4322) \]

\[c = 6.1 \text{ (cm)}\]

4. Is the brake self-locking?

\[\text{TEST } \beta \cos \theta \geq \alpha \]

\[^{2.5 \left( 2.84 \right)} > 7.5 \]

\[^{7.1 \leq 7.5} \quad \text{NO, (NOT SELF-LOCKING).} \]
VIB2. A machine vibrates in a free damped fashion when subjected to an initial displacement (i.e. free damped vibration). Test measurements indicate that its motion can be quantified as a single degree of freedom system according to the following empirical equation:

\[ X(t) = X_0 e^{-\frac{\zeta}{2}} \sin \left( \frac{\omega_n}{\zeta} t + \phi \right) \]

1. Determine the damped natural frequency.
   \[ \omega_d = 2.03 \text{ RAD/s} \]

2. Determine the phase angle.
   \[ \phi = 14.3^\circ \]

3. Determine the undamped natural frequency and damping ratio.
   \[ \omega_n = 2.03 \quad \xi = \frac{\zeta}{\omega_n} \]
   \[ (2.03)^2 = \omega_n^2 \left( 1 - \frac{\xi^2}{\omega_n^2} \right) \]
   \[ 4.1 = \omega_n^2 - 0.81 \implies \omega_n = 2.11 \text{ RAD/s} \]
   \[ \zeta = \frac{\omega_n}{2\pi} = 0.35 \text{ Hz} \]

4. Determine the ratio of magnitudes between cycles (i.e. logarithmic decrement)

\[ S = \text{Log Decrement} = \ln \frac{X_n}{X_{n+1}} = \frac{2\pi \xi}{\sqrt{1-\xi^2}} \]

Since \( \xi = \frac{\zeta}{\omega_n} = \frac{0.9}{2.11} = 0.43 \)

\[ \ln \frac{X_n}{X_{n+1}} = \frac{2\pi (0.43)}{\sqrt{1-0.43^2}} = 2.82 \]

\[ \frac{X_n}{X_{n+1}} = e^{2.82} = 16.9 \text{ TIMES} \]

OR \( X_{n+1} = \frac{1}{16.9} X_n \approx 0.059 \approx 5.9\% \text{ of previous} \)