

The question describes a classic industrial power transmission scenario using a flat-belt drive system. Unlike the previous problem, this question **does not provide a belt material density or specific weight**. Because no specific mass data is provided for the belt, centrifugal tension (F_c) cannot be quantified. In professional board exam practice, when density parameters are omitted, centrifugal effects are assumed to be negligible ($F_c = 0$). Sizing and load distributions are therefore governed purely by static friction mechanics and basic power-velocity relations.

Part 1: Determination of the Effective Belt Pull (F_e)

Step 1: Calculation of Linear Belt Velocity (v)

The absolute power transmitted by a belt depends on its linear speed. Since the belt travels seamlessly over the driving pulley rim, its linear velocity (v) matches the peripheral speed of the 615 mm pulley rotating at 630 rpm.

To maintain standard metric consistency (meters and seconds), convert the diameter to meters ($D = 0.615$ m) and the rotational speed to revolutions per second:

$$v = \frac{\pi DN}{60} = \frac{\pi(0.615 \text{ m})(630 \text{ rpm})}{60} = 20.2863 \frac{\text{m}}{\text{s}}$$

Step 2: Calculating Net Effective Force (F_e)

The net effective pull (F_e), or driving force, represents the pure structural tension differential between the tight side (F_1) and the slack side (F_2). This net force is what directly transfers torque from the driving pulley to the belt.

Using the fundamental relationship for mechanical power ($P = F_e v$), where power $P = 40$ kW = 40,000 W:

$$F_e = (F_1 - F_2) = \frac{P}{v} = \frac{40 \frac{\text{kN}}{\text{m}^2}}{20.2863 \frac{\text{m}}{\text{s}}} = 1.972 \text{ kN}$$

Notice that the tight-side tension ($F_1 = 3,795.15$ N) is nearly double the net force doing actual work ($F_e = 1,971.77$ N). This dynamic occurs because a significant baseline tension must always be maintained on the slack side (F_2) to create enough pressure against the pulley to prevent slipping.