PROBLEM 2.40

KNOWN: An expression for the power developed by an automobile engine in terms of torque and rotational speed is given.

FIND: For power, in hp, torque, in ft·lbf, and rotational speed, in RPM, evaluate the value and units of the constant appearing in the given expression.

ANALYSIS: The given expression is $\dot{W} = \mathcal{T}\omega / C$. When $\dot{W}$ is in hp, $\mathcal{T}$ is in ft·lbf, and ω is in RPM, by inspection the units of C are $\left[\frac{(\text{ft}\cdot\text{lbf})(\text{rev/min})}{\text{hp}}\right]$ ←

Beginning with $\dot{W} = \mathcal{T}\omega$, (Eq. 2.20), and applying unit conversion factors for the product $\mathcal{T}\omega$, we get

$$\dot{W} = \mathcal{T}(\text{ft}\cdot\text{lbf})\,\omega\left(\frac{\text{rev}}{\text{min}}\right)\left|\frac{2\pi\,\text{rad}}{1\,\text{rev}}\right|\left|\frac{1\,\text{min}}{60\,\text{s}}\right|\left|\frac{1\,\text{hp}}{550\,\text{ft}\cdot\text{lbf/s}}\right|$$

(in hp)

$$= \mathcal{T}(\text{ft}\cdot\text{lbf})\,\omega\left(\frac{\text{rev}}{\text{min}}\right)\left[\frac{1\,\text{hp}}{5252\,(\text{ft}\cdot\text{lbf})(\text{rev/min})}\right]$$

$$\therefore \quad \dot{W} = \frac{\tau(\text{ft}\cdot\text{lbf})\,\omega\left(\frac{\text{rev}}{\text{min}}\right)}{C}$$

(in hp)

where

$$C = 5252\,\frac{(\text{ft}\cdot\text{lbf})(\text{rev/min})}{\text{hp}}$$ ←