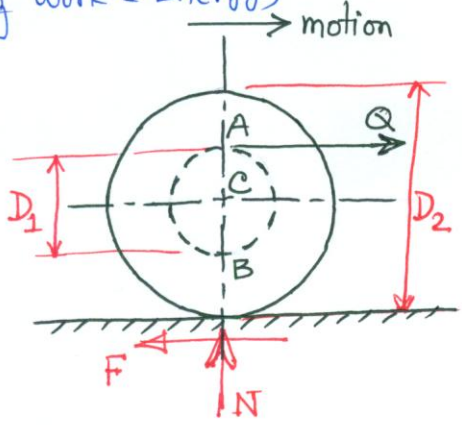
1445/PP. 421-422

(Using Work & Energy)



Grooved cylinder, rolling

$W = 322$ lb

$S_c = 54$ ft

$D_1 = 18$ inch $= 1'5$ ft

$D_2 = 36$ inch $= 3'0$ ft

$\bar{I} = 10$ slug-ft^2

$\bar{v}_0 = 0$, $\bar{v}_f = 45$ fps

$Q = ?$

Soln

As the cylinder is rolling, the friction force F does no work

See Art. 280/P. 401

$$\Delta KE = \frac{1}{2}\frac{W}{g}\bar{v}_f^2 + \frac{1}{2}\bar{I}\omega_f^2 \quad \text{[Taking c.g. as the ref. point]}$$

$$= \frac{1}{2}\times\frac{322}{32'2}\times 45^2 + \frac{1}{2}\times 10\times 30^2 \quad \Big| \quad \omega_f = \frac{\bar{v}_f}{r} = \frac{45}{3/2} = 30 \text{ rad/s.}$$

$$= 14625 \text{ lb-ft}$$

Let S_Q be the displacement of the point of application of Q

$$\therefore \theta = \frac{S_Q}{\frac{D_2}{2}+\frac{D_1}{2}} = \frac{S_c}{\frac{D_2}{2}} \quad \text{[Taking instantaneous center as reference point]}$$

$$\Rightarrow \frac{S_Q}{1'5+0'75} = \frac{54}{1'5}$$

$$\therefore S_Q = \frac{54}{1'5}\times 2'25 = 81 \text{ ft}$$

$\therefore$ Net work done, $U_{net} = Q \cdot S_Q = Q \times 81$ lb-ft

According to principles of work and kinetic energy

$$U_{net} = \Delta KE$$

$$\Rightarrow 81Q = 14625$$

$$\therefore Q = \boxed{180'6 \text{ lb}} \quad \text{Ans.}$$