Chapter 10 Problem 59 [†]

Given
$D = 0.90\ m$
$m = 120\ kg$
$F = 75\ N$
$\Delta\theta = 1/8\ rev$

Solution
Find the final angular speed of the potter's wheel.

Since all the work goes into rotational motion, the work energy theorem states that the work is equal to the final rotational kinetic energy.

$$W = \tau\Delta\theta$$

$$K = \tfrac{1}{2}I\omega^2$$

Setting $W = K$ and solving for angular velocity gives

$$\tfrac{1}{2}I\omega^2 = \tau\Delta\theta$$

$$\omega = \sqrt{\frac{2\tau\Delta\theta}{I}}$$

Assuming the force is applied tangent to the edge of the potter's wheel, the torque is $\tau = rF$. Since the wheel is a solid disk, the moment of inertia is $I = \frac{1}{2}mr^2$. Substituting these into the angular velocity formula gives

$$\omega = \sqrt{\frac{2rF\Delta\theta}{\frac{1}{2}mr^2}} = \sqrt{\frac{4F\Delta\theta}{mr}}$$

The change in angle converted into radians is $\pi/4$. Solving for the angular velocity gives

$$\omega = \sqrt{\frac{4(75\ N)(\pi/4\ rad)}{(120\ kg)(0.45\ m)}}$$

$$\omega = 2.09\ rad/s$$

[†]Problem from Essential University Physics, Wolfson