Task:

When a cycle moving with force (f) applied on the pedal then what is the resultant force applied on the gear of the cycle and what is the loss of original force i. e. force applied on the pedal and the force applied on the gear

Solution:

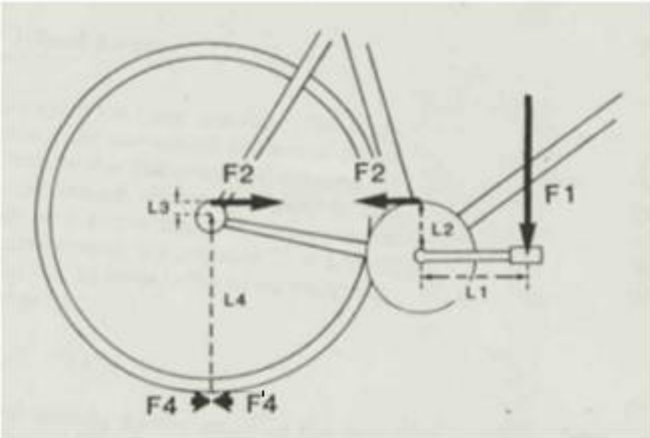

Figure 2.4: Propagation of tangential force from the pedal to the wheel. Force F_4 denotes the force exerted by the road on the tire, which is in the opposite direction to the force applied by the wheel on the road.

The propagation of the force from the pedal to the wheel is outlined in Figure 2.4. The tangential force F_1 that the cyclist applies to the pedal causes a torque τ_1 about the crank axis. The magnitude of a torque is defined as the product of the force and the length of the lever arm, here denoted as L_1. Thus it follows:

$$\tau_1 = F_1 \cdot L_1 \ .$$

The sprockets and the chain act as a torque converter. In cycling a low speed and a high torque at the crank are usually converted to a higher speed with a smaller torque at the rear sprocket.
The force F_2 in the chain multiplied by the radius of the front sprocket L_2 equals τ_1. Thus, F_2 can be obtained from

$$F_2 = F_1 \cdot \frac{L_1}{L_2} \ . \qquad (2.2)$$

Then the torque τ_2 at the rear is defined by the product of F_2 and the radius of the rear sprocket L_3:

$$\tau_2 = F_2 \cdot L_3 \ . \tag{2.3}$$

Besides, τ_2 can be determined by means of the force applied to the wheel F'_4[1] and the wheel radius L_4:

$$\tau_2 = F'_4 \cdot L_4 \ . \tag{2.4}$$

Hence, using (2.2), (2.3) and (2.4), for the force F'_4 at the wheel it follows

$$F'_4 = F_2 \cdot \frac{L_3}{L_4} = F_1 \cdot \frac{L_1}{L_2} \cdot \frac{L_3}{L_4} \ .$$

In reality, force transmission is not perfect, due to friction losses in the internal machinery as the chain, gear train and bearing. Those losses are rather a minor factor. According to Gregor et al. they make up less than 5% of the overall resistive forces . Kyle denotes the amount of power input lost due to friction by 3% to 5% .