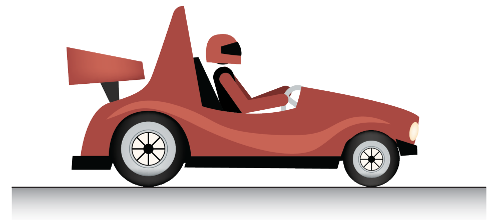
22-R-WE-JL-25



A 1600 kg racecar is travelling along a straight road at a constant speed of 60 km/h. If the motor is outputting 60 kW, what is the coefficient of friction of the road?

Later that day, another car (with identical tires) takes the same route, but it is not as efficient as the racecar. The input power supplied to the engine is 74 kW, but this only results in a constant speed of 45 km/h. Given the efficiency of the second car to be $\eta = 0.4$, determine it's mass.

Solution

Since the car is travelling at a constant speed, we have $a = 0$. Therefore, we can sum the forces in the x and y components and solve.

$$\sum F_x : F_{car} - F_{friction} = 0 \implies F_{car} = \mu_k \cdot N$$

$$\sum F_y : N - mg = 0 \implies N = mg = (1600)(9.81) = 15700 \quad [\text{N}]$$

Next, relating the power and velocity of the car, we can make a substitution for $\mu_k \cdot N$ and solve for the coefficient of friction. Converting the speed of the car into m/s gives $v = 60\frac{km}{h} = 16.67\frac{m}{s}$.

$$P_{out} = \vec{F}_{car} \cdot \vec{v} = F_{car}\, v = \big(\mu_k \cdot N\big)\, v$$

$$P_{out} = \big(\mu_k \cdot mg\big)\, v \implies \mu_k = \frac{P}{mgv} = \frac{60000}{1600 \cdot 9.81 \cdot 16.67} = 0.229$$

Then for the second car, it is also travelling at constant speed ($a = 0$), and since it travels the same route, the coefficient of friction is the same. Converting the speed into units of m/s yields $v = 45\frac{km}{h} = 12.5\frac{m}{s}$. Finally, using the same expression for the output power as in part 1, we get:

$$\eta = \frac{P_{out}}{P_{in}} = \frac{\mu_k\, mg\, v}{P_{in}}$$

Rearranging and solving, we have:

$$m = \frac{\eta\, P_{in}}{\mu_k\, g\, v} = \frac{0.4 \cdot 74000}{0.229 \cdot 9.81 \cdot 12.5} = 1054 \quad [\text{kg}]$$