Centripetal Force and Frictional Force Calculations

Problem Statement

A car travels at constant speed around a horizontal circular corner of radius 5 m.

(a) Given that the car just starts to skid if its speed is 12 km/h, find the frictional force acting on the car.

(b) Assuming the same frictional force is acting, calculate the car's smallest possible turning radius if the speed is 30 km/h.

(c) Calculate the turning radius for the car traveling at 12 km/h in wet conditions where the frictional force is halved.

Solution

Part (a)

The frictional force provides the centripetal force required to keep the car moving in a circle. The centripetal force is given by:

$$F = \frac{mv^2}{r}$$

To find the frictional force F, we first convert the speed from km/h to m/s:

$$v = 12\,\text{km/h} = \frac{12 \times 1000}{3600}\,\text{m/s}$$

$$v = \frac{10}{3}\,\text{m/s}$$

The radius r of the circular path is 5 m. Assuming the mass of the car is m (which is not provided and not necessary for the calculation as we will see), the frictional force F at the point of skidding is:

$$F = \frac{mv^2}{r}$$

$$F = \frac{m\left(\frac{10}{3}\right)^2}{5}\,\text{N}$$
$$F = \frac{100m}{9 \times 5}\,\text{N}$$
$$F = \frac{20m}{9}\,\text{N}$$

Part (b)

The frictional force calculated in part (a) remains the same, and we want to find the smallest possible turning radius r for a speed of 30 km/h. First, we convert the speed:

$$v = 30\,\text{km/h} = \frac{30 \times 1000}{3600}\,\text{m/s}$$
$$v = \frac{25}{3}\,\text{m/s}$$

Using the same frictional force F from part (a), we find the new radius r:

$$F = \frac{mv^2}{r}$$

$$\frac{20m}{9} = \frac{m\left(\frac{25}{3}\right)^2}{r}$$
$$\frac{20}{9} = \frac{625}{9r}$$
$$r = \frac{625}{20}\,\text{m}$$
$$r = 31.25\,\text{m}$$

Part (c)

In wet conditions, the frictional force is halved, so we have:

$$F = \frac{20m}{9 \times 2}\,\text{N}$$

Using the original speed of 12 km/h ($\frac{10}{3}$ m/s), we calculate the new turning radius r:

$$\frac{20m}{18} = \frac{m\left(\frac{10}{3}\right)^2}{r}$$
$$\frac{20}{18} = \frac{100}{9r}$$
$$r = \frac{100}{10}\,\text{m}$$
$$r = 10\,\text{m}$$

Conclusion

By analyzing the frictional force required for centripetal motion, we have calculated the frictional force acting on a car turning at 12 km/h, the smallest turning radius possible at 30 km/h assuming the same frictional force, and the turning radius at 12 km/h when the frictional force is halved due to wet conditions.