

A photograph of a motorcycle accident on a racetrack. A rider in a red and yellow racing suit and a helmet with a star pattern is lying on the asphalt. The motorcycle is on its side, and a large fire is burning from the engine area. The background is a dark, paved surface.

Motorcycle Dynamics

Resistance To Motion

Resistance To Motion



We will look at 3 types of resistance to motion –

- Aero Drag Force

$$F_D = \frac{1}{2}\rho \times C_D \times A \times V^2$$

- Rolling Resistance

$$F_w = 0.02 \times m \times g$$

- Resistance Due To Gradient (Road Plane)

$$F_P = m \times g \times \sin\theta$$

Resistance To Motion

- Aero Drag Force

$$F_D = \frac{1}{2}\rho \times C_D \times A \times V^2$$

Where –

ρ = Density of Air (1.167 kg/m³ @ 20°C and 987 mbar)

C_D = Drag Coefficient

A = Frontal Area

V = Velocity

Resistance To Motion

- Rolling Resistance

$$F_w = 0.02 \times m \times g$$

Where –

m = Total Mass

g = Gravity (9.81 m/s^2)

Resistance To Motion

- Resistance Due To Gradient (Road Plane)

$$F_P = m \times g \times \sin\theta$$

Where –

m = Total Mass

g = Gravity (9.81 m/s^2)

θ = Angle of road plane

Resistance To Motion

- Example 1

Consider a bike with the following parameters –

$$M = 200 \text{ kg}$$

$$A = 0.6 \text{ m}^2$$

$$C_D = 0.7$$

$$V = 200 \text{ km/h}$$

- A) What force is needed to reach 200 km/h?
- B) What force is needed to reach the same speed up a 12% slope?

Resistance To Motion

First you need V in m/s –

$$V = 200 \times \frac{1000}{3600} = 55.55 \text{ m/s}$$

A) Total force required = $F_D + F_W$, therefore –

$$F = (\frac{1}{2}\rho \times C_D \times A \times V^2) + (0.02 \times m \times g)$$

$$F = (\frac{1}{2} \times 1.167 \times 0.7 \times 0.6 \times 55.55^2) + (0.02 \times 200 \times 9.81)$$

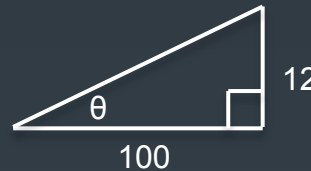
$$F = 756.24 + 39.24$$

$$F = 795.48 \text{ N}$$

Resistance To Motion

First we need the angle of the road plane –

$$\tan\theta = \frac{12}{100}$$



$$\theta = \tan^{-1} \frac{12}{100}$$
$$\theta = 6.8^\circ$$

B) Total force required = $F_D + F_W + F_P$, therefore –

$$F = 795.48 \text{ (from A)} + (m \times g \times \sin\theta)$$

$$F = 795.48 + (200 \times 9.81 \times \sin 6.8)$$

$$F = 795.48 + 232.31$$

$$F = 1027.79 \text{ N}$$

Resistance To Motion

■ Example 2

Consider a bike with the following parameters –

$$M = 250 \text{ kg}$$

$$C_D A = 0.305 \text{ m}^2$$

- A) What power is needed to reach 250 km/h?
- B) What power is needed to reach 250 km/h up a 10% slope?
- C) What power is needed to reach 275 km/h?
- D) What power is needed to reach 275 km/h up a 10% slope?

Resistance To Motion

First you need V in m/s –

$$V = 250 \times \frac{1000}{3600} = 69.44 \text{ m/s}$$

A) $\text{Power} = F \times V$

But $F = \text{Total resistance} = F_D + F_W$, therefore –

$$F = (\frac{1}{2}\rho \times C_D A \times V^2) + (0.02 \times m \times g)$$

$$F = (\frac{1}{2} \times 1.167 \times .305 \times 69.44^2) + (0.02 \times 250 \times 9.81)$$

$$F = 854.14 + 49.05$$

$$F = 907.19 \text{ N}$$

Resistance To Motion



So we have the force needed, now to calculate the power –

$$P = F \times V$$

$$P = 907.19 \times 69.44$$

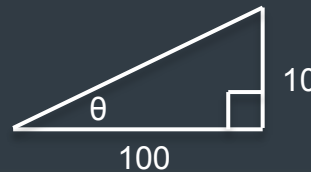
$$P = 62995.27 \text{ w}$$

$$P = 63 \text{ kw}$$

Resistance To Motion

B) First we need the angle of the road plane –

$$\tan\theta = \frac{10}{100}$$



$$\theta = \tan^{-1} \frac{10}{100}$$
$$\theta = 5.71^\circ$$

Total force required = $F_D + F_W + F_P$, therefore –

$$F = 907.19 \text{ (from A)} + (m \times g \times \sin\theta)$$

$$F = 907.19 + (250 \times 9.81 \times \sin 5.71)$$

$$F = 907.19 + 244$$

$$F = 1151.19 \text{ N}$$

Resistance To Motion



So we have the force needed, now to calculate the power –

$$P = F \times V$$

$$P = 1151.19 \times 69.44$$

$$P = 79938.63 \text{ w}$$

$$P = 79.94 \text{ kw}$$

Resistance To Motion

First you need the new V in m/s –

$$V = 275 \times \frac{1000}{3600} = 76.39 \text{ m/s}$$

C) $\text{Power} = F \times V$

As before $F = \text{Total resistance} = F_D + F_W$, therefore –

$$F = \left(\frac{1}{2}\rho \times C_D A \times V^2\right) + (0.02 \times m \times g)$$

$$F = \left(\frac{1}{2} \times 1.167 \times .305 \times 76.39^2\right) + (0.02 \times 250 \times 9.81)$$

$$F = 1038.52 + 49.05$$

$$F = 1087.57 \text{ N}$$

Resistance To Motion



So we have the force needed, now to calculate the power –

$$P = F \times V$$

$$P = 1087.57 \times 76.39$$

$$P = 83079.47 \text{ w}$$

$$P = 83.08 \text{ kw}$$

Resistance To Motion

D) Using the angle of the road plane from B –

Total force required = $F_D + F_W + F_P$, therefore –

$$F = 1087.57 \text{ (from C)} + 244 \text{ (from B)}$$

$$F = 1087.57 + 244$$

$$F = 1331.57 \text{ N}$$

$$\text{And now } P = F \times V$$

$$P = 1331.57 \times 76.39$$

$$P = 101718.63 \text{ w}$$

$$P = 101.72 \text{ kw}$$