1. Car on a Sloping Road

(a) Resistive Force

When the car moves at a constant speed, the net force is zero. Let the direction down the slope be positive. The forces along the slope are the driving force (F_{engine}), the component of gravity ($mg\sin(\theta)$), and the resistive force ($F_{\text{resistive}}$). The equation is:

$$F_{\text{engine}} + mg\sin(\theta) - F_{\text{resistive}} = 0$$

The driving force is calculated from the power ($P = 112.5\,\text{kW}$) and speed ($v = 20\,\text{m/s}$):

$$F_{\text{engine}} = \frac{P}{v} = \frac{112500\,\text{W}}{20\,\text{m/s}} = 5625\,\text{N}$$

The gravitational component is:

$$F_g = mg\sin(10^\circ) = (1200\,\text{kg})(9.81\,\text{m/s}^2)\sin(10^\circ) \approx 2043.6\,\text{N}$$

Solving for the resistive force:

$$F_{\text{resistive}} = F_{\text{engine}} + F_g = 5625\,\text{N} + 2043.6\,\text{N} = 7668.6\,\text{N} \approx \mathbf{7670}\,\text{N}$$

(b) Minimum Braking Force

The total stopping distance is 40 m. The process has two stages:

1. **Reaction Time:** Distance covered in $t_{\text{reaction}} = 0.5\,\text{s}$ is $d_{\text{reaction}} = v \times t_{\text{reaction}} = 20 \times 0.5 = 10\,\text{m}$.
2. **Braking:** Remaining distance is $d_{\text{braking}} = 40\,\text{m} - 10\,\text{m} = 30\,\text{m}$.

The required acceleration to stop in 30 m is found using $v_f^2 = v_i^2 + 2ad$:

$$0^2 = (20)^2 + 2a(30) \implies a = -\frac{400}{60} = -\frac{20}{3} \approx -6.67\,\text{m/s}^2$$

Applying Newton's Second Law during braking (engine is off):

$$F_{\text{net}} = mg\sin(10^\circ) - F_{\text{resistive}} - F_{\text{brake}} = ma$$

$$F_{\text{brake}} = mg\sin(10^\circ) - F_{\text{resistive}} - ma$$

$$F_{\text{brake}} = 2043.6 - 7668.6 - (1200)(-\frac{20}{3}) = -5625 + 8000 = \mathbf{2375}\,\text{N}$$

(c) Impulse During Impact

The new braking force is $F'_{\text{brake}} = 0.95 \times 2375\,\text{N} = 2256.25\,\text{N}$. The new acceleration is:

$$a' = \frac{mg\sin(10^\circ) - F_{\text{resistive}} - F'_{\text{brake}}}{m} = \frac{2043.6 - 7668.6 - 2256.25}{1200} \approx -6.568\,\text{m/s}^2$$

The speed just before impact after traveling 30 m is:

$$v_{\text{impact}}^2 = v_i^2 + 2a'd = (20)^2 + 2(-6.568)(30) = 5.92 \implies v_{\text{impact}} \approx 2.43\,\text{m/s}$$

The impulse (J) is the change in momentum. Assuming the car stops after impact ($v_{\text{final}} = 0$):

$$J = \Delta p = mv_{\text{final}} - mv_{\text{impact}} = 0 - (1200\,\text{kg})(2.43\,\text{m/s}) = -2916\,\text{Ns}$$

The magnitude of the impulse is **2920** Ns.