

The Physics of Falling

To determine the arresting force needed to bring a falling mass to zero velocity, we must use Newton’s *impulse-momentum theorem*. The arresting force will be dependent on the time it takes to decelerate the falling mass to zero velocity.

In a 2.0m test fall, a 100 kg object will have an instantaneous velocity of -6.26 m/s at the moment of impact. (Note: Acceleration is a constant 9.8m/sec² for all falling objects).

The average force needed to reduce the falling objects velocity from an initial -6.26 m/s to a final 0 (zero) m/s is given by the following equation:

$$(equation 1) \quad F = \frac{mv_f - mv_i}{\Delta t} = \frac{\Delta P}{\Delta t}$$

Where F = the average force; m = mass; V_f = final velocity and V_i = initial velocity.

Table 1: These calculations assume no air resistance

CALCULATIONS FOR A PERSON OF MASS 100 kg				
Time	Displacement $y = \frac{1}{2} at^2$	Velocity at displacement y SI unit = m/s $v = at$	Acceleration $g = 9.8 \text{ m/sec}^2$ Remains constant!	Initial momentum at displacement y SI unit = kg m/s $P = mv$
After 0.3499 sec freefall	-0.60 m (600mm)	-3.4292 m/s (12.3 kph)	-9.8 m/sec ²	-342.92 kg m/s
After 0.612 sec freefall	-1.836 m	-6.0 m/s (21.6 kph)	-9.8 m/sec ²	-600 kg m/s
After 0.6388 sec freefall	-2.0 m	-6.26 m/s (22.5 kph)	-9.8 m/sec²	-626 kg m/s
After 0.8571 sec freefall	-3.6 m	-8.4 m/s (30.24 kph)	-9.8 m/sec ²	-840 kg m/s
After 0.9035 sec freefall	-4.0 m	-8.85 m/s (31.86 kph)	-9.8 m/sec ²	-885 kg m/s
After 1.0 sec freefall	-4.9 m	-9.8 m/s (35.28 kph)	-9.8 m/sec ²	-980 kg m/s
After 2.0 sec freefall	-19.6 m	-19.6 m/s (70.56 kph)	-9.8 m/sec ²	-1960 kg m/s
After 3.0 sec freefall	-44.1 m	-29.4 m/s (105.84 kph)	-9.8 m/sec ²	-2940 kg m/s

Table 2: These calculations assume an inelastic collision.

Calculations based on 626 kg m/s momentum after 2.0m free-fall. [The force of the fall is dependent on the time it takes to decelerate the falling mass to zero velocity]		
TIME Δt	AVERAGE FORCE	Equivalent weight (kg)
0.01 sec	62600 N (62.6 kN)	6.2 tons or 62g
0.04173 sec	15000 N (15 kN)	1.5 tons or 15g
0.05 sec	12520 N (12.52 kN)	1.2 tons or 12g
0.1 sec	6260 N (6.26 kN)	626 kg or more than 6g
0.10433 sec	6000 N (6.0 kN)	600 kg or 6g
0.2 sec	3130 N (3.13 kN)	313 kg or 3g

