

## Providing Further Insight into the Shock-Resistant Rating of Watches

by Michael de Silva<sup>1</sup>, 24.04.2007

For these calculations we are considering the following assumptions. The watch weighs  $m = 0.2kg$  (or 200g), the acceleration due to gravity  $g = 9.81ms^{-2}$ , and finally the height from which it falls  $s = 5m$ .

From the equations of linear motions it can be calculated as follows,

$$s = ut + \frac{1}{2}at^2 \quad (1)$$

$$t = \sqrt{\frac{2s}{a}} \quad (2)$$

The time taken for the object to fall from a height of 5m, and it is only after this time has passed that the object experiences ‘impact’, is calculated as follows,

$$t \simeq 1s \quad (3)$$

The *impact velocity* maybe obtained by equating KE=PE,

$$\frac{1}{2}mv^2 = mgh \quad (4)$$

$$v = \sqrt{2gh} = \sqrt{\frac{10}{9.81}} = 9.905ms^{-1} \quad (5)$$

The Kinetic Energy just before impact is,

$$KE = \frac{1}{2}mv^2 = 9.81J \quad (6)$$

The Work-Energy Principle states that, “*The change in the kinetic energy of an object is equal to the net work done on the object.*” For a straight-line collision, the net work done is equal to the average force of impact times the distance traveled during the impact,

**Average impact force x distance traveled = change in kinetic energy**

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<sup>1</sup><http://www.bsodmike.com/contact>

This can be mathematically described as follows,

$$F_{Avg} \cdot d = \Delta KE = KE_{Final} - KE_{Initial} \quad (7)$$

$$F_{Avg} = \frac{9.81}{d} = \frac{9.81}{0.0001} = 98100N \quad (8)$$

From this, the deceleration, can be considered as acceleration for now (after all it is only 'negative' acceleration).

$$a = \frac{F}{m} = \frac{98100}{0.2} = \frac{490500}{9.81} = 50,000g \quad (9)$$

Calculating the duration which the deceleration occurs is as follows,

$$a = \frac{(v - u)}{t} \quad (10)$$

$$t = \frac{(v - u)}{a} = \frac{9.81}{490500} = 0.02ms \quad (11)$$

Equations 10-11 are purely for informative purposes, while it is equation 9 that is significant. The 'deceleration' experienced by this 200g watch is  $490500ms^{-2}$  or in other words  $50,000g$ 's.

Find on the following page a tabulation of the 'deceleration' experienced by watches (or objects) of different masses, dropped at different heights onto a hard surface such as a granite or marble floor (defined by  $d$ ).

Going back to equation (11) it can be seen that this object experiences a deceleration of  $50,000g$ 's during a period of  $0.02ms$ , after the initial  $1s$  as shown by equation (3), during which the object travelled the entire  $5m$  drop - thus impacting on the surface of the floor.

The results from the tabulated data make the following relationship quite clear, with regards to impact force situations,

$$-a \propto \left\{ \frac{s}{d} \right\} \quad (12)$$

I have marked this as ' $-a$ ' to denote deceleration<sup>2</sup>.

**I would like to thank the members of the  $\Omega$ TZ forum<sup>3</sup> for their contribution and insight into this extremely rewarding hobby :)**

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<sup>2</sup>Deceleration is simply *negative* acceleration.

<sup>3</sup><http://forums.timezone.com>

## Tabulation of the Deceleration Experienced

by objects of different masses, dropped at different heights onto a hard surface such as a granite or marble floor (defined by  $d$ )

### $d = 0.1\text{mm}$

s	m	v	KE	d	$F_{\text{avg}}$	a (in g's)
1.00	0.05	4.43	0.49	0.0001	4905.00	10000.00
1.00	0.10	4.43	0.98	0.0001	9810.00	10000.00
1.00	0.15	4.43	1.47	0.0001	14715.00	10000.00
1.00	0.20	4.43	1.96	0.0001	19620.00	10000.00
2.00	0.05	6.26	0.98	0.0001	9810.00	20000.00
2.00	0.10	6.26	1.96	0.0001	19620.00	20000.00
2.00	0.15	6.26	2.94	0.0001	29430.00	20000.00
2.00	0.20	6.26	3.92	0.0001	39240.00	20000.00
5.00	0.05	9.90	2.45	0.0001	24525.00	50000.00
5.00	0.10	9.90	4.91	0.0001	49050.00	50000.00
5.00	0.15	9.90	7.36	0.0001	73575.00	50000.00
5.00	0.20	9.90	9.81	0.0001	98100.00	50000.00
10.00	0.05	14.01	4.91	0.0001	49050.00	100000.00
10.00	0.10	14.01	9.81	0.0001	98100.00	100000.00
10.00	0.15	14.01	14.72	0.0001	147150.00	100000.00
10.00	0.20	14.01	19.62	0.0001	196200.00	100000.00

### $d = 0.01\text{mm}$

s	m	v	KE	d	$F_{\text{avg}}$	a (in g's)
1.00	0.05	4.43	0.49	0.00001	49050.00	100000.00
1.00	0.10	4.43	0.98	0.00001	98100.00	100000.00
1.00	0.15	4.43	1.47	0.00001	147150.00	100000.00
1.00	0.20	4.43	1.96	0.00001	196200.00	100000.00
2.00	0.05	6.26	0.98	0.00001	98100.00	200000.00
2.00	0.10	6.26	1.96	0.00001	196200.00	200000.00
2.00	0.15	6.26	2.94	0.00001	294300.00	200000.00
2.00	0.20	6.26	3.92	0.00001	392400.00	200000.00
5.00	0.05	9.90	2.45	0.00001	245250.00	500000.00
5.00	0.10	9.90	4.91	0.00001	490500.00	500000.00
5.00	0.15	9.90	7.36	0.00001	735750.00	500000.00
5.00	0.20	9.90	9.81	0.00001	981000.00	500000.00
10.00	0.05	14.01	4.91	0.00001	490500.00	1000000.00
10.00	0.10	14.01	9.81	0.00001	981000.00	1000000.00
10.00	0.15	14.01	14.72	0.00001	1471500.00	1000000.00
10.00	0.20	14.01	19.62	0.00001	1962000.00	1000000.00

**Note:** Please note that the acceleration (or in this it should be called 'deceleration') has been divided by 'g', to give the answer as a multiple of the acceleration due to gravity.