Shock absorber

Formulae and examples of calculation

A shock absorber decelerates linearly. Roughly 90% of shock absorber applications can be modelled if the following 4 factors are known:

1. Mass to slow down	m (kg)	2. Impact velocity	v_D (m/s)
3. Propelling force	F (N)	4. Shocks per hour	C (hr)

Symbols used in the formulae:

W_1	Kinetic energy	(Nm)	M	Propelling torque	(Nm)
W_2	Propelling energy	(Nm)	I	Moment of inertia	(kgm^2)
W_3	Total energy per cycle (W_1+W_2)	(Nm)	g	Gravity = 9,81	(m/s^2)
W_4	Total energy per hour (W_3 C)	(Nm/hr)	h	Drop height exc. shock abs. stroke	(m)
me	Effective weight	(kgme)	s	Shock absorber stroke	(m)
m	Mass to slow down	(kg)	Q	Reactive force	(N)
*v	Velocity or moving mass	(m/s)	μ	Friction coefficient	
*v_D	Impact velocity of shock absorber	(m/s)	t	Braking time	(sec)
ω	Angular velocity	(rad/s)	a	Deceleration	(m/sec^2)
F	Propelling force	(N)	α	Side load angle	(°)
C	Number of Shocks per hour	(/hr)	β	Angle of inclination	(°)
P	Motor power	(kW)	L	Radius of mass	(m)
ST	Setting coefficient (normally 2.5)	1 to 2.5	R	Dist. pivot/installation pt. of damp.	(m)
			r	Dist. pivot/force application pt.	(m)

*v or v_D is the impact velocity of the mass. In the case of an acceleratedmovement (for example when the mass is deplaced by a pneumatic cylinder), **the impact velocity can be 1.5 to 2 times greater than the average velocity.**

1. Mass without propelling force

Formulae:

$W_1 = m \cdot v^2 \cdot 0,5$

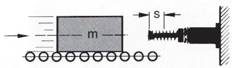
$W_2 = 0$

$W_3 = W_1 + W_2$

$W_4 = W_3 \cdot C$

$V_D = V$

$me = m$



2. Mass with propelling force

Formulae:

$W_1 = m \cdot v^2 \cdot 0,5$

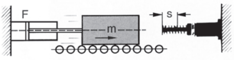
$W_2 = F \cdot s$

$W_3 = W_1 + W_2$

$W_4 = W_3 \cdot C$

$V_D = V$

$me = \frac{2 \cdot W_3}{V_D^2}$



2.1 Mass moving upwards

$W_2 = (F - m \cdot g) \cdot s$

2.2 Mass moving downwards

$W_2 = (F + m \cdot g) \cdot s$

3. Mass pulled by a motor

Formulae:

$W_1 = m \cdot v^2 \cdot 0,5$

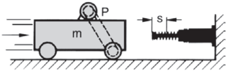
$W_2 = \frac{1000 \cdot P \cdot ST \cdot s}{v}$

$W_3 = W_1 + W_2$

$W_4 = W_3 \cdot C$

$V_D = V$

$me = \frac{2 \cdot W_3}{V_D^2}$



4. Mass on motorised rollers

Formulae:

$W_1 = m \cdot v^2 \cdot 0,5$

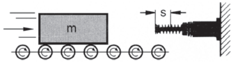
$W_2 = m \cdot \mu \cdot g \cdot s$

$W_3 = W_1 + W_2$

$W_4 = W_3 \cdot C$

$V_D = V$

$me = \frac{2 \cdot W_3}{V_D^2}$



5. Swinging mass with propelling force

Formulae:

$W_1 = m \cdot v^2 \cdot 0,5$

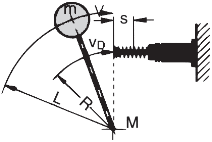
$W_2 = \frac{M \cdot s}{R}$

$W_3 = W_1 + W_2$

$W_4 = W_3 \cdot C$

$V_D = \frac{V \cdot R}{L} = \omega \cdot R$

$me = \frac{2 \cdot W_3}{V_D^2}$



Formulae and examples of calculation

6. Free falling mass

Formulae:

$W_1 = m \cdot g \cdot h$

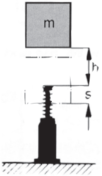
$W_2 = m \cdot g \cdot s$

$W_3 = W_1 + W_2$

$W_4 = W_3 \cdot C$

$v_D = \sqrt{2 \cdot g \cdot h}$

$me = \frac{2 \cdot W_3}{v_D^2}$



6.1 Mass rolling or sliding on an inclined plane

Formulae:

$W_1 = m \cdot g \cdot h = m \cdot v_D^2 \cdot 0{,}5$

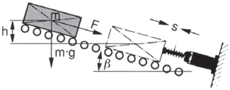
$W_2 = m \cdot g \cdot \sin\beta \cdot s$

$W_3 = W_1 + W_2$

$W_4 = W_3 \cdot C$

$v_D = \sqrt{2 \cdot g \cdot h}$

$me = \frac{2 \cdot W_3}{v_D^2}$



6.1a Mass with upwards propelling force

$W_2 = (F - m \cdot g \cdot \sin b) \cdot s$

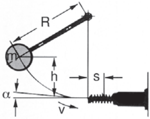
6.1b Mass with downwards propelling force

$W_3 = (F + m \cdot g \cdot \sin b) \cdot s$

6.2 Mass free falling abut a pivot point

Formulae: Follow calculation for example 6.1. Verify the radial load.

$\tan \alpha = \frac{s}{R}$



7. Rotary index table with propelling torque

Formulae:

$W_1 = m \cdot v^2 \cdot 0{,}25$

$W_2 = \frac{M \cdot s}{R}$

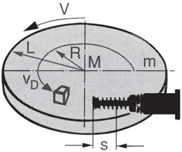
$W_3 = W_1 + W_2$

$W_4 = W_3 \cdot C$

$v_D = \frac{v \cdot R}{L} = \omega \cdot R$

$me = \frac{2 \cdot W_3}{v_D^2}$

NOTE: mass evenly spread.



8. Rotating mass with propelling torque

Formulae:

NOTE: mass evenly spread.

$W_1 = m \cdot v^2 \cdot 0{,}18$

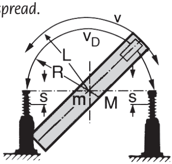
$W_2 = \frac{M \cdot s}{R}$

$W_3 = W_1 + W_2$

$W_4 = W_3 \cdot C$

$v_D = \frac{v \cdot R}{L} = \omega \cdot R$

$me = \frac{2 \cdot W_3}{v_D^2}$



9. Rotating mass with propelling force

Formulae:

NOTE: mass evenly spread.

$W_1 = m \cdot v_D^2 \cdot 0{,}18$

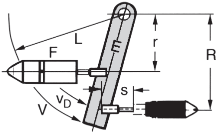
$W_2 = \frac{F \cdot r \cdot s}{R} = \frac{M \cdot s}{R}$

$W_3 = W_1 + W_2$

$W_4 = W_3 \cdot C$

$v_D = \frac{v \cdot R}{L} = \omega \cdot R$

$me = \frac{2 \cdot W_3}{v_D^2}$



10. Mass in controlled descent without propelling force

Formulae:

$W_1 = m \cdot v^2 \cdot 0{,}5$

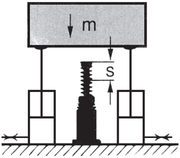
$W_2 = m \cdot g \cdot s$

$W_3 = W_1 + W_2$

$W_4 = W_3 \cdot C$

$v_D = v$

$me = \frac{2 \cdot W_3}{vd^2}$



Reactive force Q(N)

$Q = \frac{1{,}2 \cdot W_3}{s}$

Braking time (s)

$t = \frac{2{,}6 \cdot s}{v_D}$

Deceleration (m/s²)

$a = \frac{0{,}6 \cdot v_D^2}{s}$

These formulae will give you approximate values to assist in the selection of a shock absorber but a safety margin should always be applied. (Precise values can only be calculated if actual parameters are known).