Tuned Mass Damper: Optimum Tuning and Damping

Optimum frequency ratio, damping ratio, spring and dashpot of a tuned mass damper for a main mass and spring, with the resulting peak amplification.

Method: Equal-peak optimum damped vibration absorber

Input parameters

Unit system: SI

Parameter	Value	Unit
Main (structure) mass	20,000	kg
Main stiffness	8,000.0	kN/m
Absorber mass	1,000.0	kg

Calculated results

Parameter	Value	Unit
Natural frequency of the main system	3.1831	Hz
Mass ratio m_a/M	0.050000	
Optimum frequency ratio ω_a/ω_n	0.95238	
Optimum absorber damping ratio	0.12727	
Absorber spring stiffness	362.81	kN/m
Absorber damping coefficient (N·s/m)	4,848.3	
Peak amplification of the main mass (equal-peak estimate)	6.4031	

Notes for this case

• A small mass on a spring and damper attached to a vibrating structure absorbs energy near the structure's resonance. Equal-peak (fixed-point) tuning for harmonic force on an undamped main system gives the absorber natural frequency ω_a = ω_n/(1 + μ) and damping ratio ζ = √[3μ/8(1 + μ)³], leaving a peak amplification of about √(1 + 2/μ) instead of an infinite resonance. Mass ratios of 1–10 % are typical; a larger absorber mass is more robust to mistuning. Building and bridge dampers are usually tuned to the measured frequency on site.

Formula and method

$$\frac{\omega_a}{\omega_n} = \frac{1}{1+\mu}, \quad \zeta_{opt} = \sqrt{\frac{3\mu}{8(1+\mu)^3}}, \quad \frac{X}{X_{st}} \approx \sqrt{1+\frac{2}{\mu}}$$

Variables

M	Main (structure) mass	kg
K	Main stiffness	N/m
m_a	Absorber mass	kg
f_n	Natural frequency of the main system	1/s
μ	Mass ratio m_a/M	-
f_{opt}	Optimum frequency ratio ω_a/ω_n	-
ζ_{opt}	Optimum absorber damping ratio	-
k_a	Absorber spring stiffness	N/m
c_a	Absorber damping coefficient (N·s/m)	-
X/X_{st}	Peak amplification of the main mass (equal-peak estimate)	-

Method and standards

Tuned mass damper.

Assumptions and limits

- Undamped main system; harmonic force excitation; single mode.

References

Equal-peak optimum damped vibration absorber

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/mechanical/statics-dynamics/tuned-mass-damper-optimum

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Reopens the calculator with the inputs of this report.