



MECHANICAL VIBRATION

BMCG 3233

CHAPTER 1: INTRODUCTION TO VIBRATION (PART 1)

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CONTENTS

1.1 Why study vibration?

1.2 Terminologies and definitions

LEARNING OBJECTIVES

1. Recognise phenomena and applications of vibration in practice
2. Describe important terminologies in vibration





1.1

WHY STUDY VIBRATION?



Most engineering structures vibrate:

- machines, cars, aircraft, etc
- materials become lighter, more flexible, engines become faster

**Micrographs showing how
surface fatigue cracks
grow as material is further cycled.

(usually frequency of around 20-50 Hz)**

From Ewing & Humphrey, 1903

J. A. Ewing and J. C. W. Humphrey

Phil. Trans., A, vol. 200, Plate 9

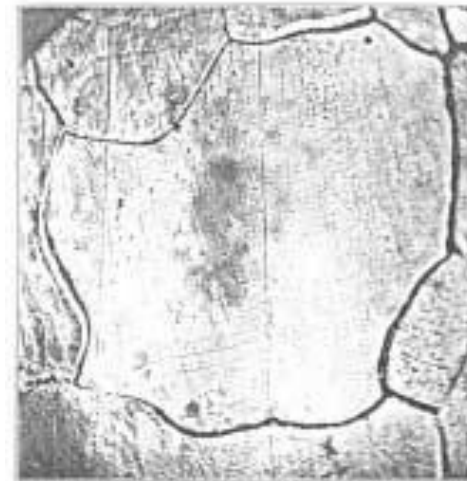


Fig. 9. Specimen after 1000 reversals of a stress of 12-4 tons per sq. inch. $\times 1000$.



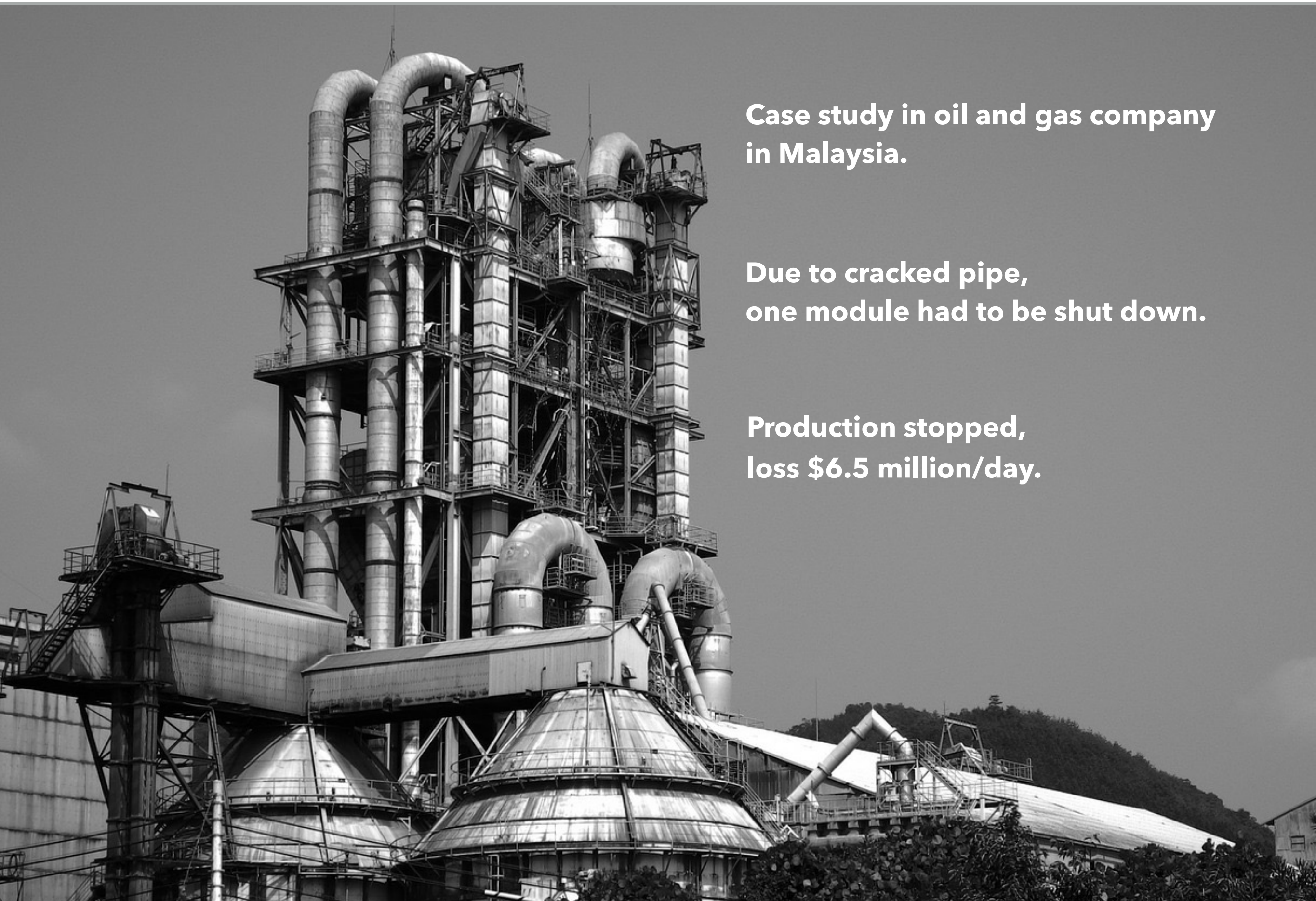
Fig. 10. Specimen after 2000 reversals. $\times 1000$.



Fig. 11. Specimen after 50,000 reversals. $\times 1000$.



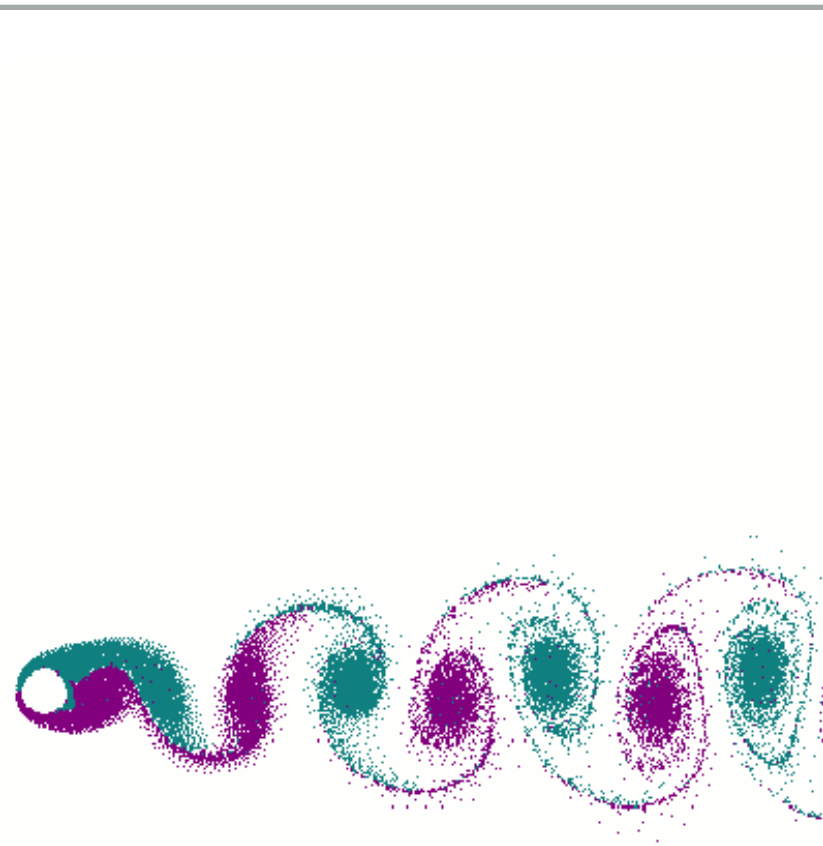
Fig. 12. Specimen after 40,000 reversals. $\times 1000$.



Case study in oil and gas company in Malaysia.

Due to cracked pipe, one module had to be shut down.

Production stopped, loss \$6.5 million/day.



GiF animation of vortex shedding credit to: Cesareo de La Rosa Siqueira

A suspension bridge, Tacoma Narrows Bridge in Washington, 1940.

The bridge collapsed due to 'vortex-induced vibration' due to the wind.

Sampoong Department Store, Seoul, 1995.

Air-conditioning (AC) unit was moved due to noise complaints.

The were cracks on the roof structure during the re-localisation of the AC unit.

Cracks were untreated, and propagated to the main supported columns due to vibration of the AC unit.

502 people died and 937 were injured.



Effects of Vibration: Structural Failure

Rana Plaza, Dhaka, Bangladesh 2013

Building supposedly designed for offices and shops were used as garment factory.

The structure could not bear the heavy weight and vibrations from the machines.

1,130 people died and 2,500 were injured.



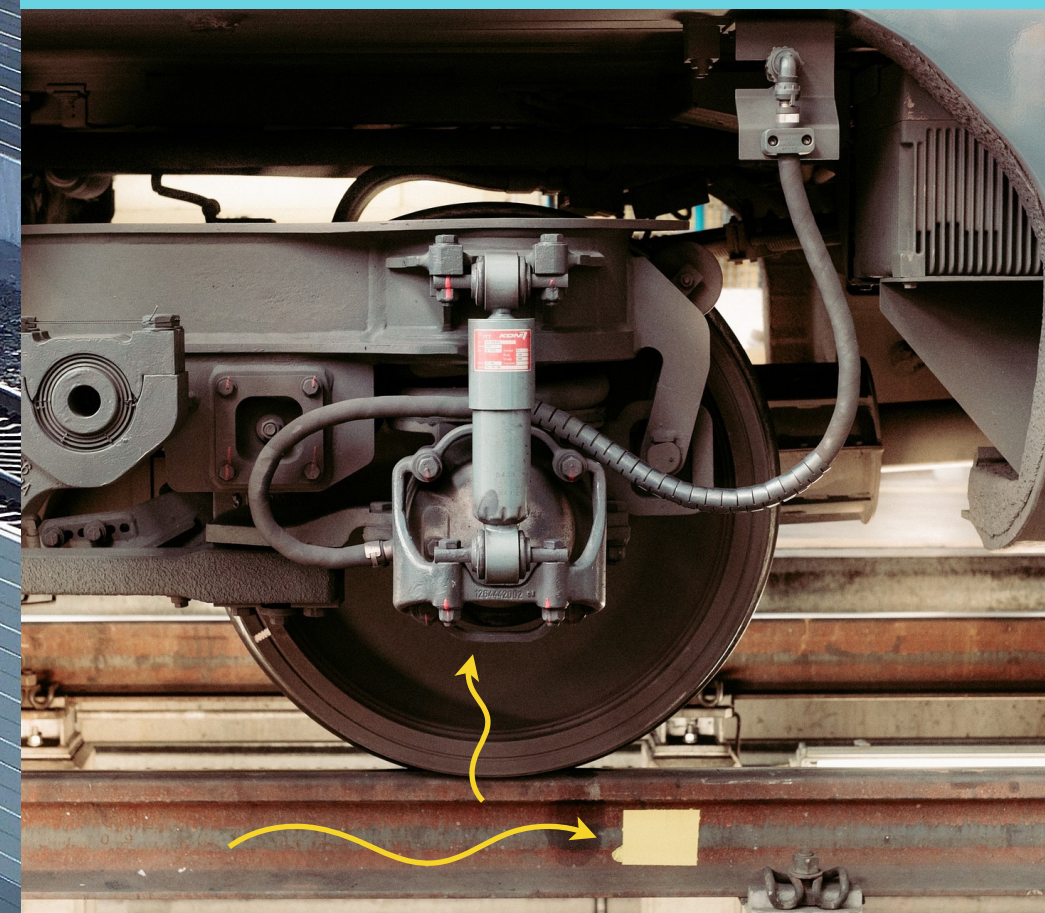
Effects of Vibration: Noise



Dominant source of noise is the 'rolling noise'.

Due to interaction between the wheel and the rail track.

Vibration of the wheel and the rail radiates noise.





Control back-pain risks from whole-body vibration

Advice for employers on the Control of Vibration at Work Regulations 2005



This is a web-friendly version of leaflet INDG242 (rev1), revised 06/05

Introduction

Who should read this leaflet?

You should read this leaflet if you employ operators of off-road mobile machinery, agricultural vehicles or industrial trucks.

You may also find it helpful if:

- you employ drivers of other vehicles, particularly if they suffer from back pain;
- you are a driver or operator of a mobile machine or vehicle;
- you are a trade union safety representative or an employee representative for drivers or operators.

This leaflet will help you manage the risk of back pain in your employees and will tell you what you need to do to comply with the Control of Vibration at Work Regulations 2005.

Most people who drive road-going vehicles at work are not likely to experience high levels of whole-body vibration and so their employers are unlikely to have to take any action under these Regulations.

See HSE leaflet INDG175(rev2) for guidance on exposure to hand-arm vibration.

HSE's priced book on whole-body vibration will give you more information on all the topics in this leaflet. (Due to be published in late 2005, ISBN 0 7176 6126 1.)

Also see HSE's vibration web pages: www.hse.gov.uk/vibration.

The health effects of whole-body vibration

What can cause or aggravate back pain in mobile machine operators and drivers?



What causes vibration?

DESIGN

Manufacturing Defect

ASSEMBLY



Installation

MAINTENANCE

Operations

Watch the video: "Introduction to Mechanical Vibration"

Scan this QR code



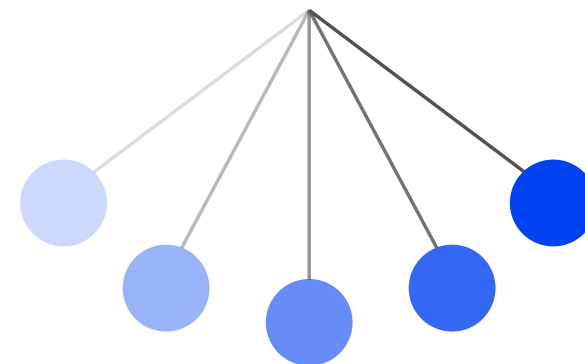
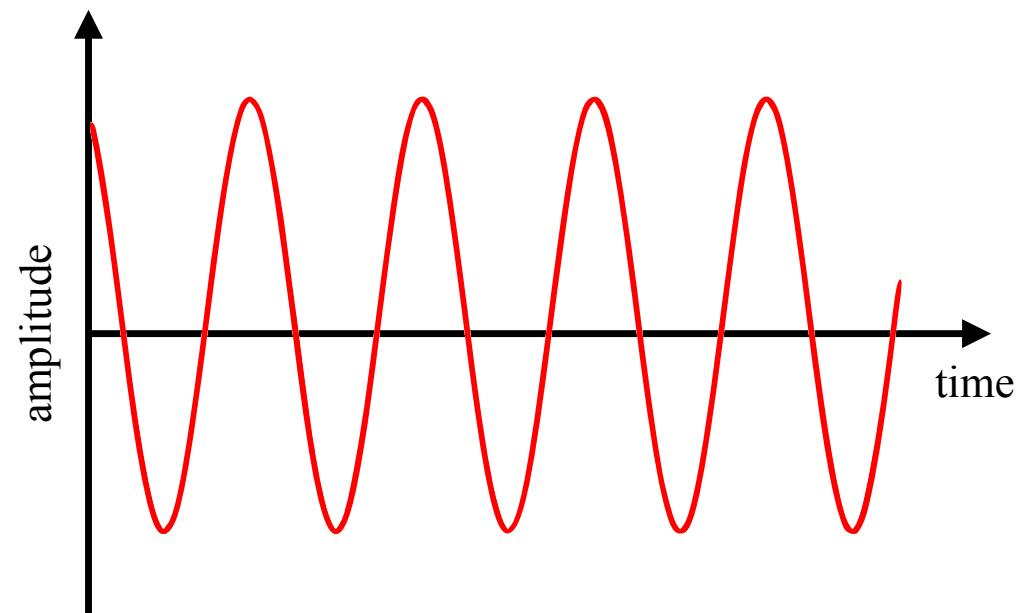
Or click/tap [here](#).



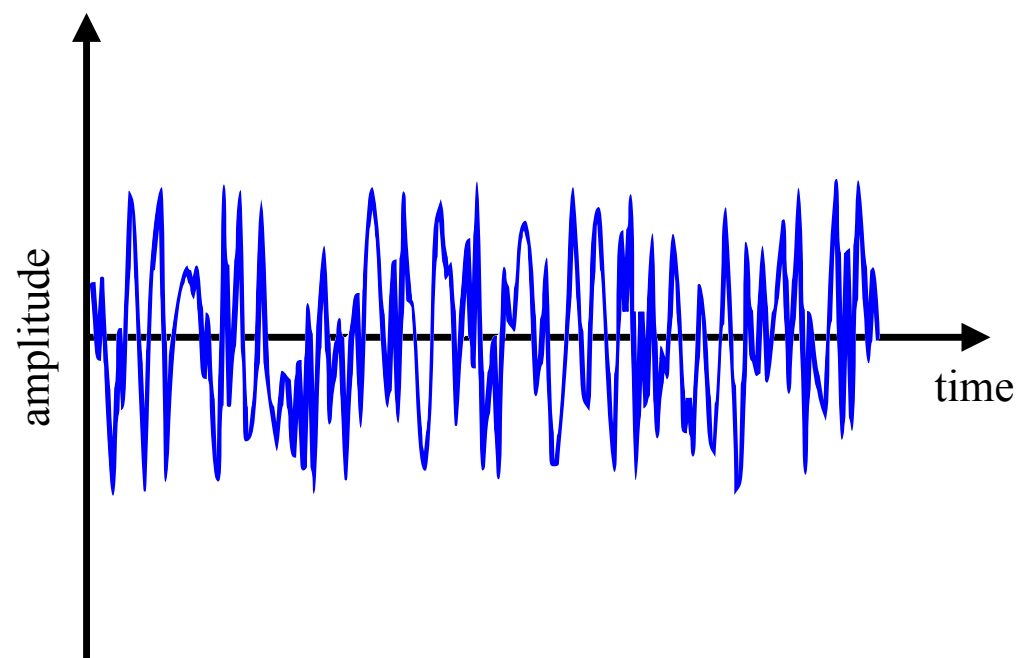
1.2

TERMINOLOGIES AND DEFINITIONS

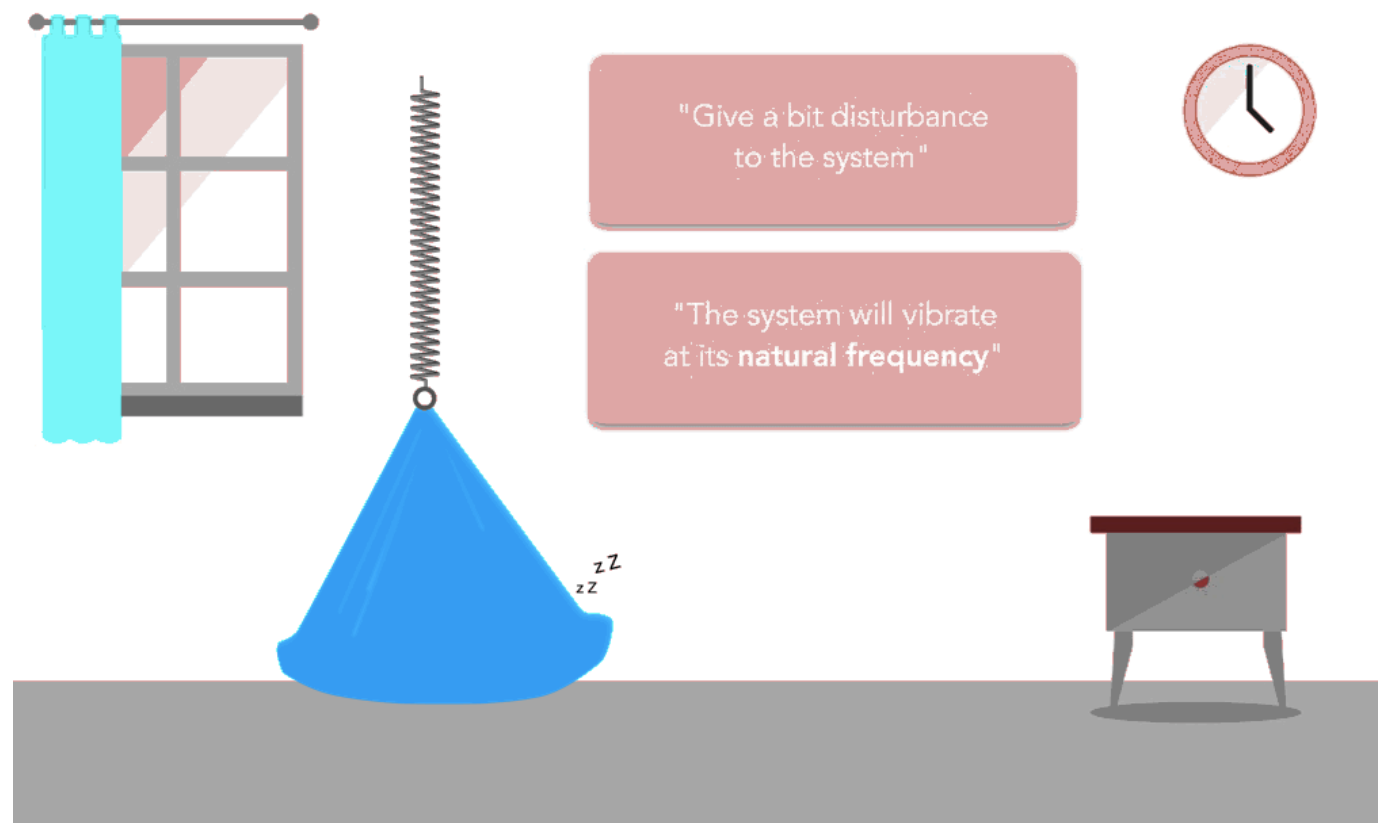
Deterministic vibration



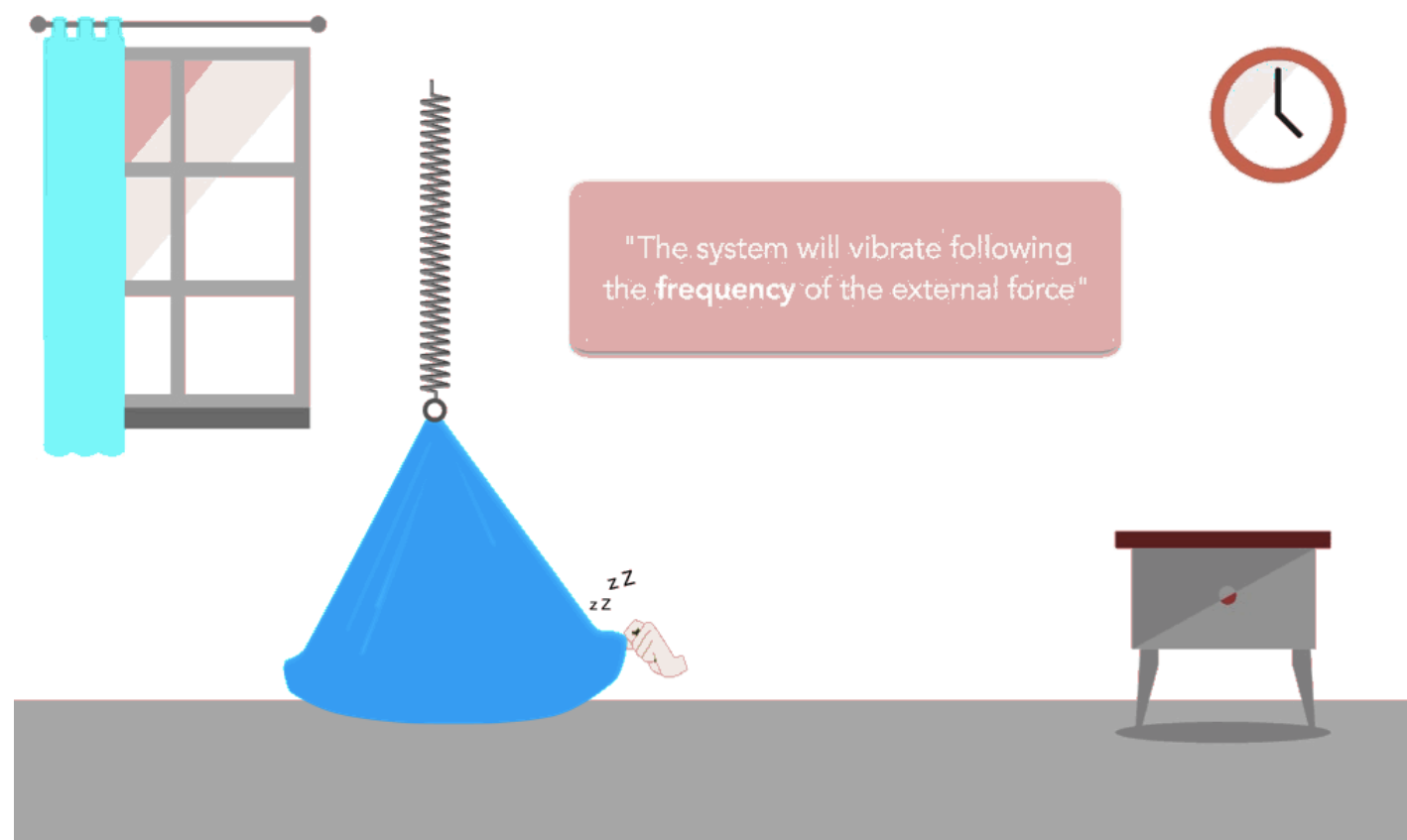
Random vibration



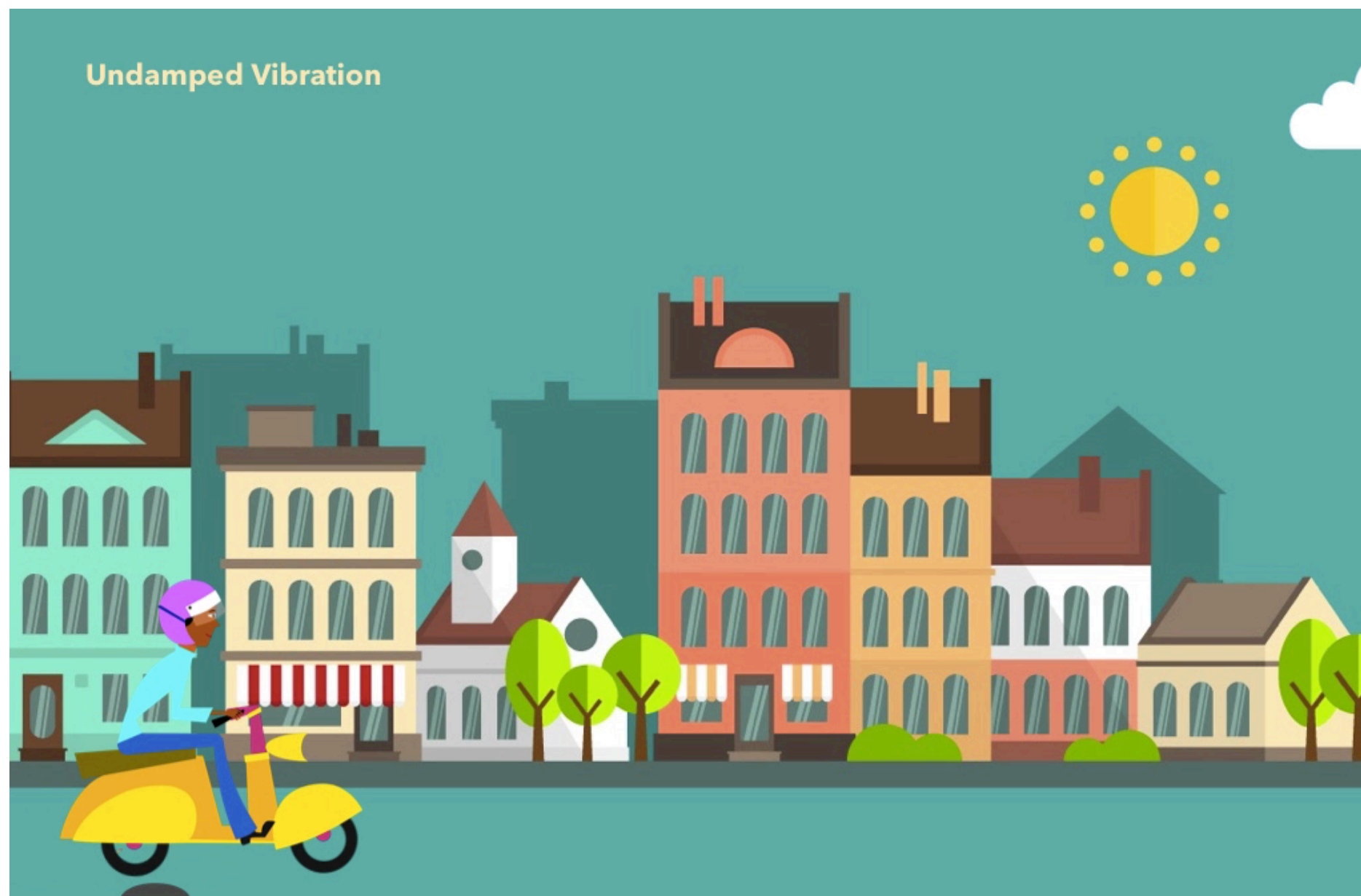
Free vibration



Forced vibration

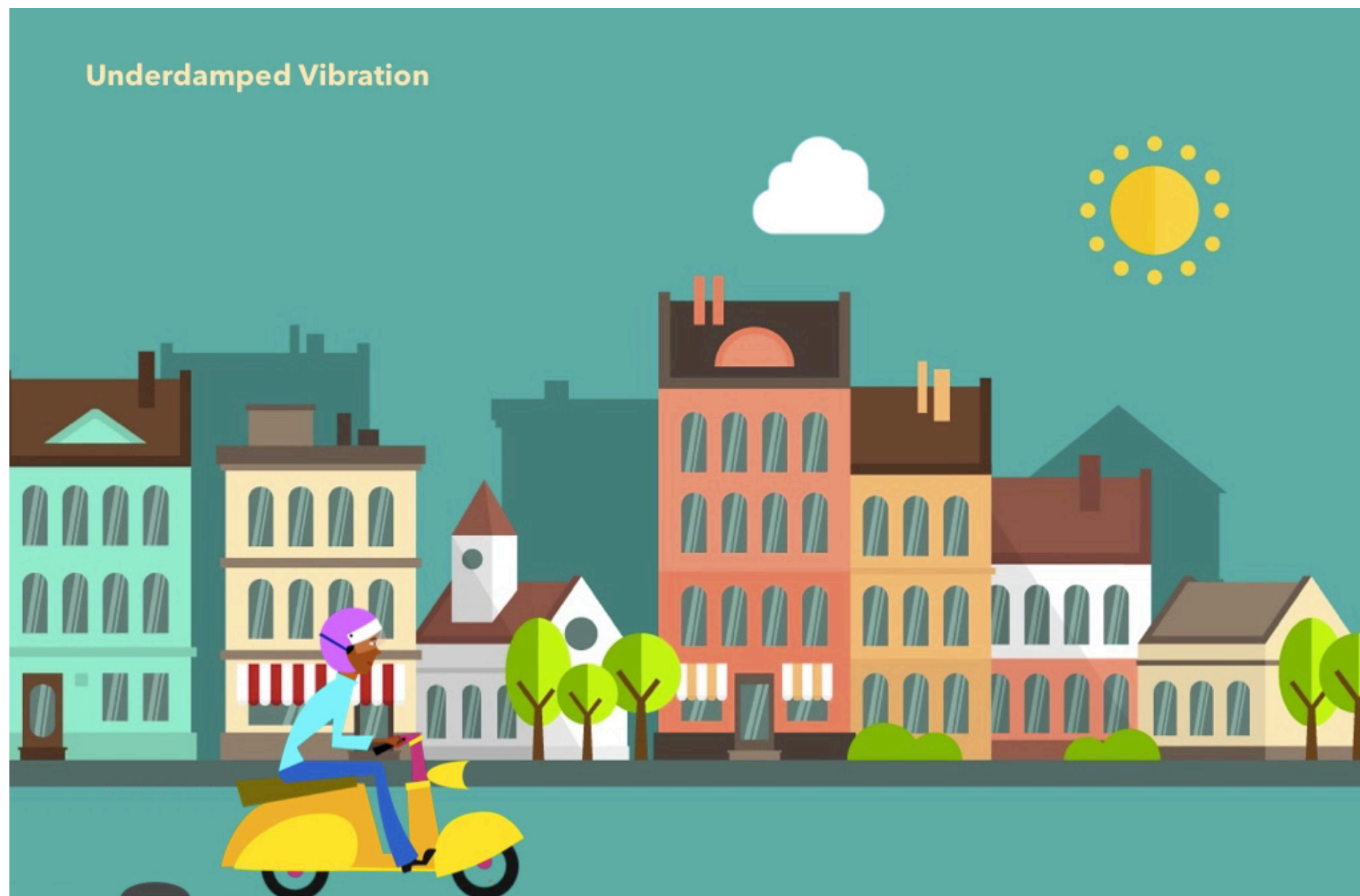


Undamped vibration



Vector image: Designed by [freepik.com](https://www.freepik.com)

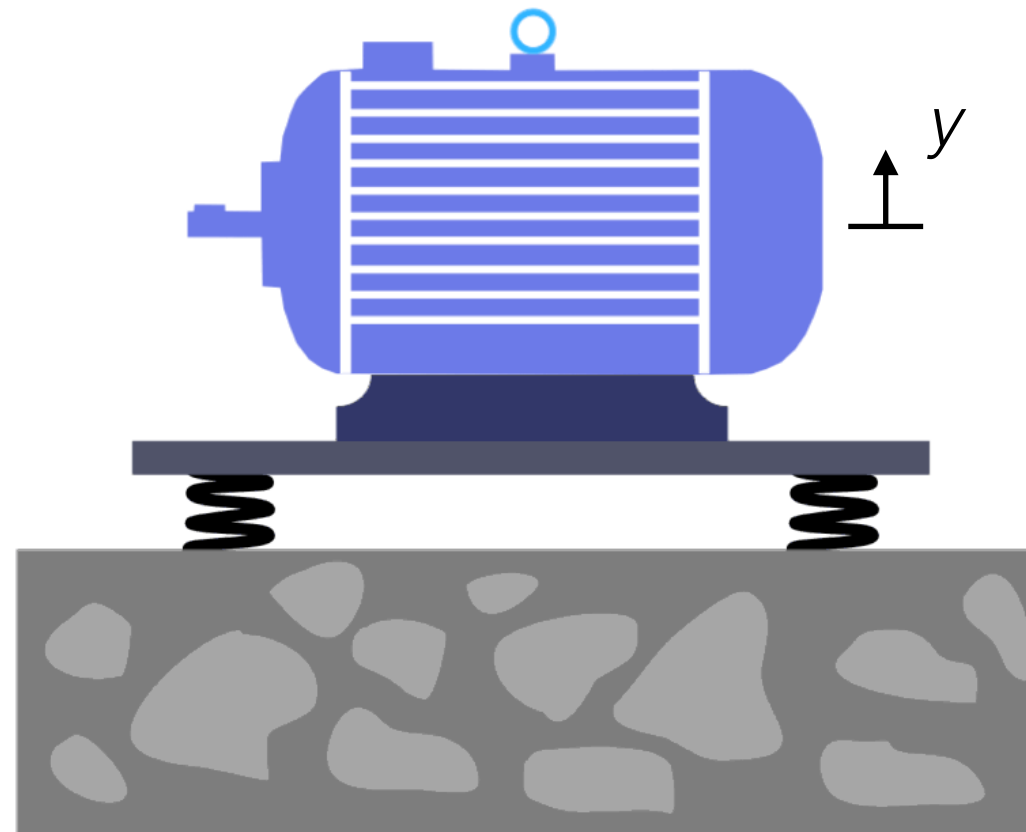
Damped vibration



Vector image: Designed by [freepik.com](https://www.freepik.com)

Degree of Freedom

“Number of **independent** coordinate to describe the motion of a system”



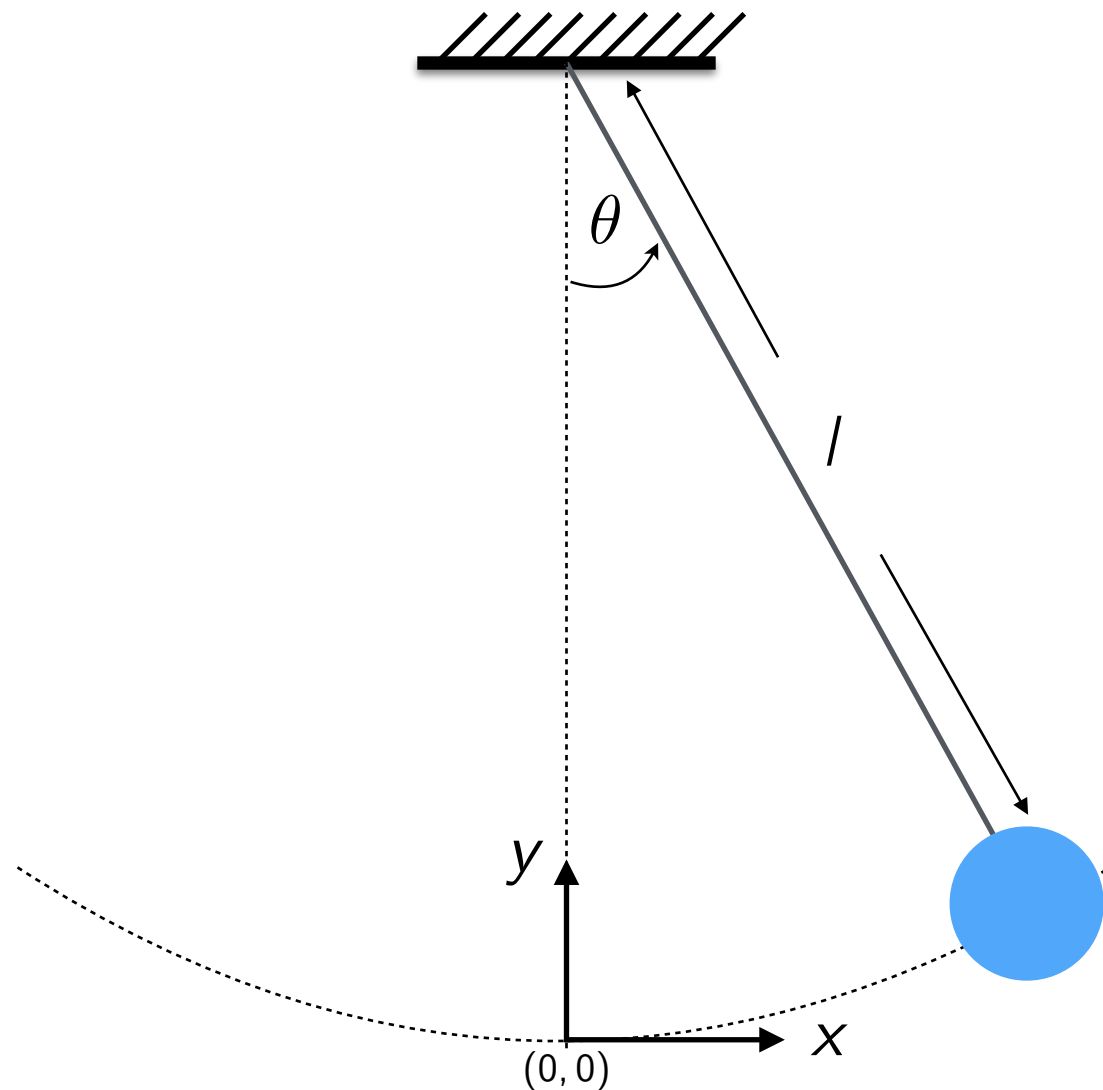
Only **y** coordinate to represent the vibration of the system.

Single-degree-of-freedom system

Degree of Freedom

$$x = l \sin \theta$$

$$y = l(1 - \sin \theta)$$



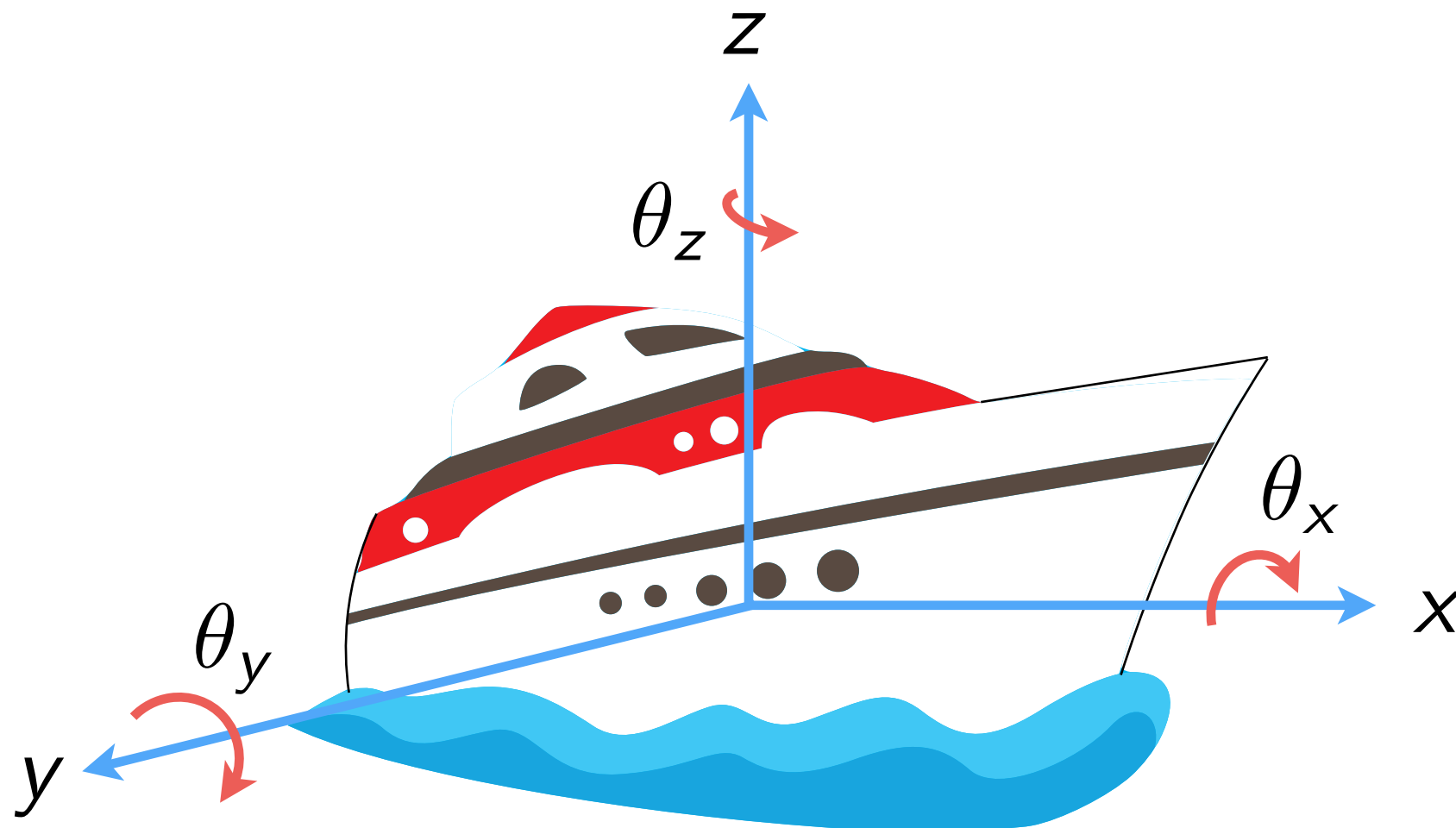
What is the **minimum** coordinate to represent the motion of the ball?

Are **x** and **y** independent coordinates?

Single-degree-of-freedom system

Degree of Freedom

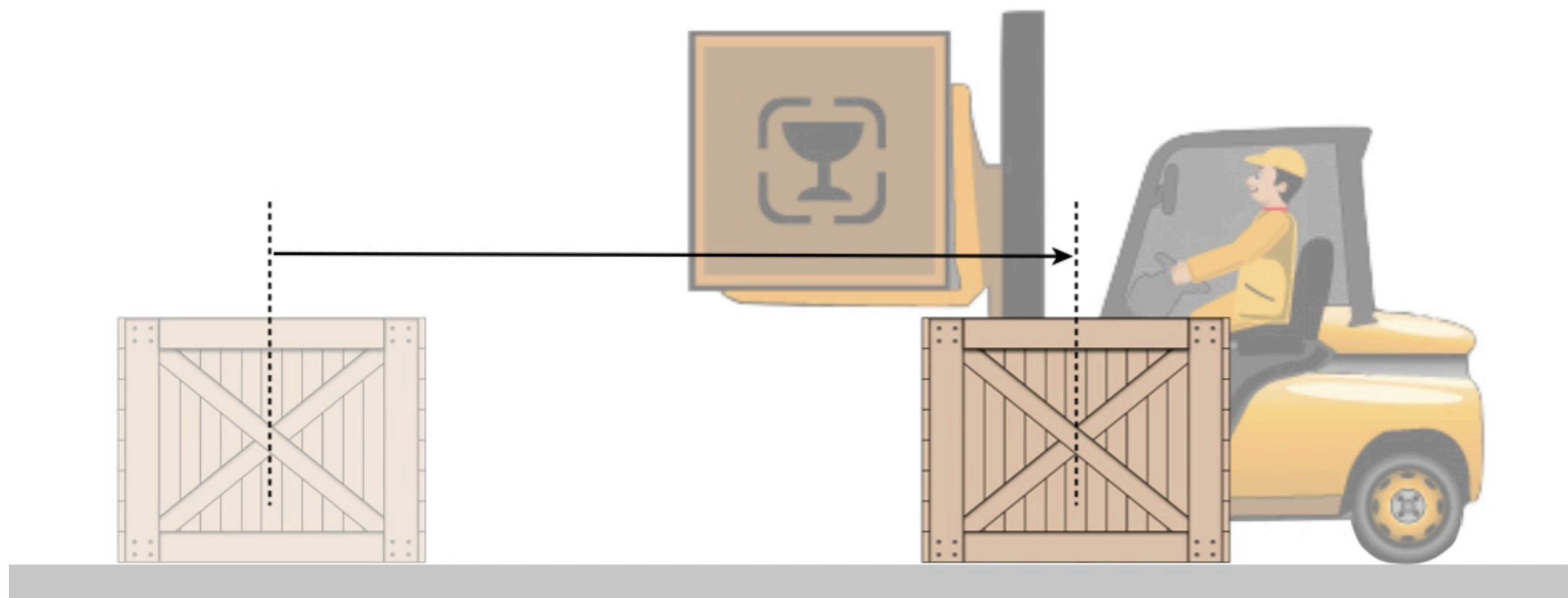
How many degrees of freedom of a sailing ship in the ocean?



Six-degree-of-freedom system

Translational motion

Displacement of the centre of gravity of a rigid body.

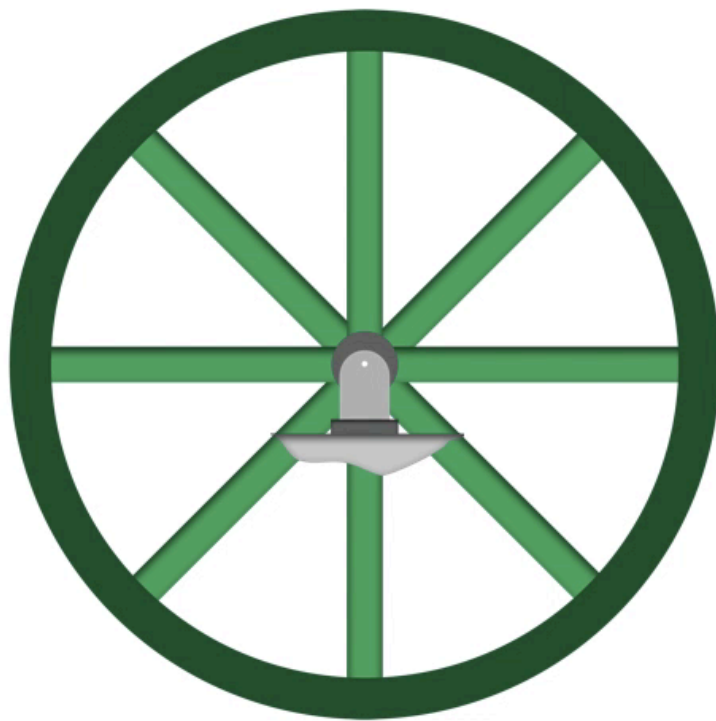


Vector image: Designed by [freepik.com](https://www.freepik.com)

Rotational motion

**Rotation of a rigid body
about a fixed axis.**

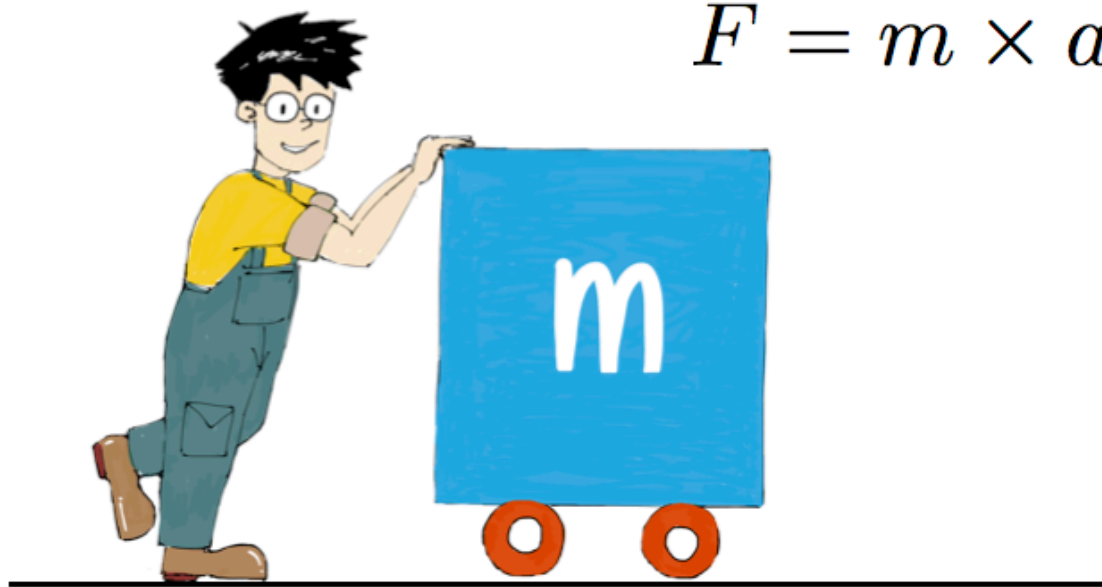
**The centre of gravity is at
the centre of rotation.**



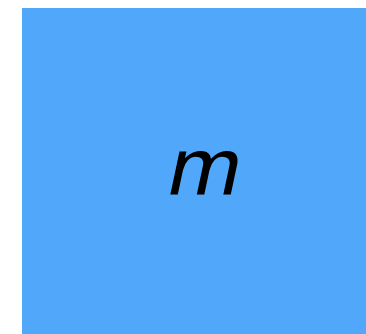
Mass Element

A rigid body. It accelerates when an external force is applied.

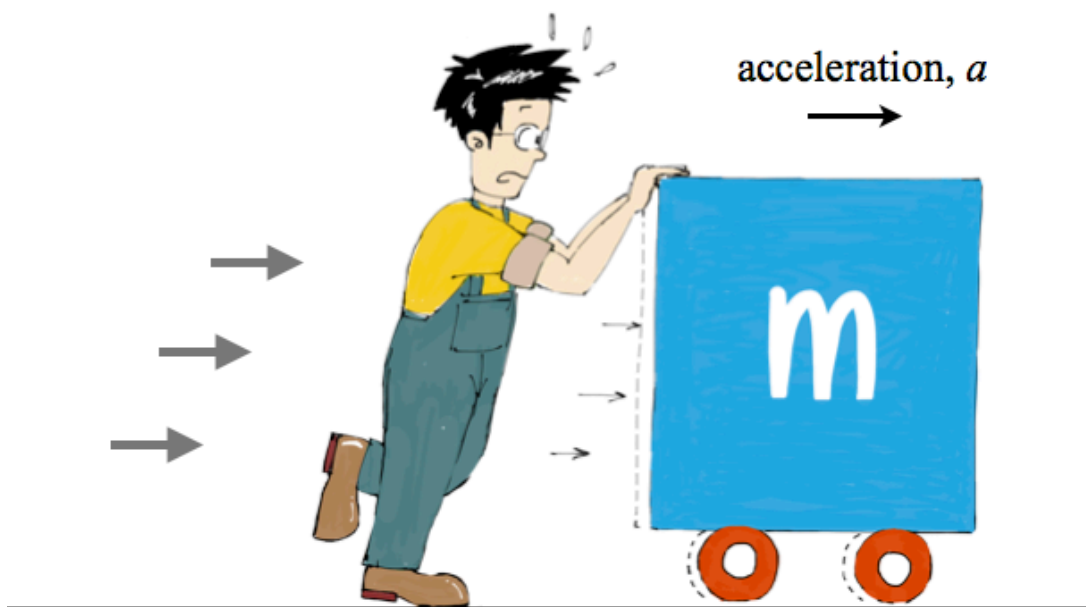
$$F = m \times a$$



Mathematical symbol:



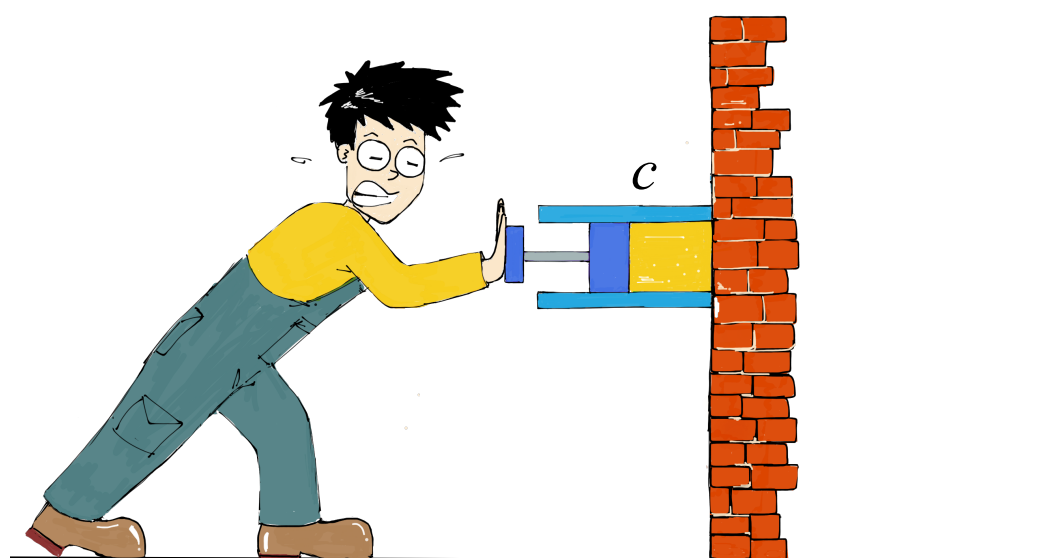
Mass [kg]



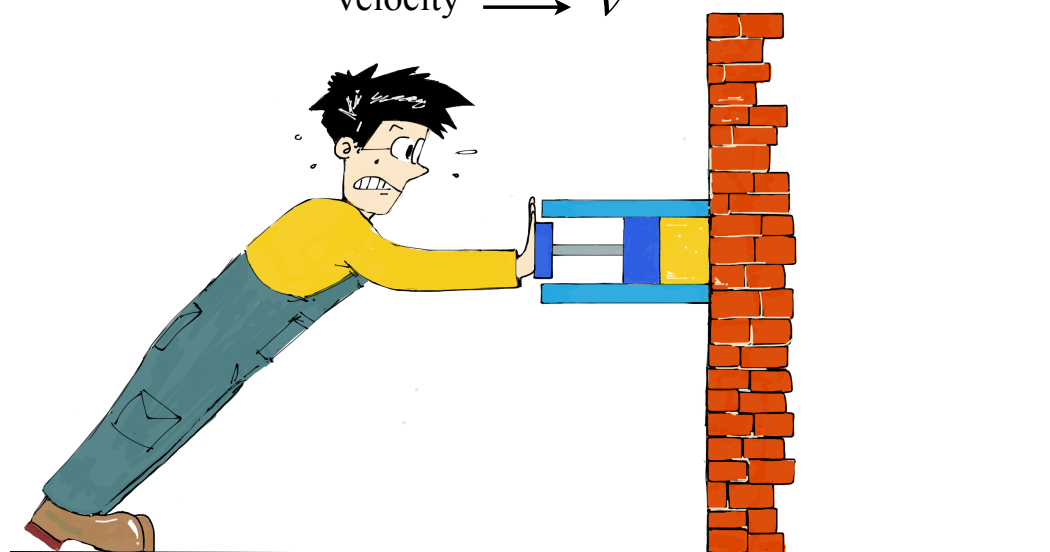
Damper element

Element that provides damping and absorbs energy of vibration.

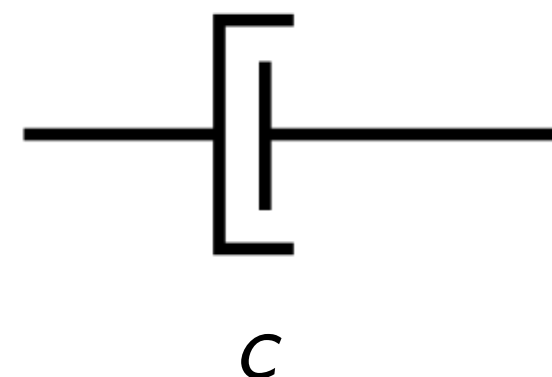
$$F = c \times v$$



velocity $\rightarrow v$



Mathematical symbol:

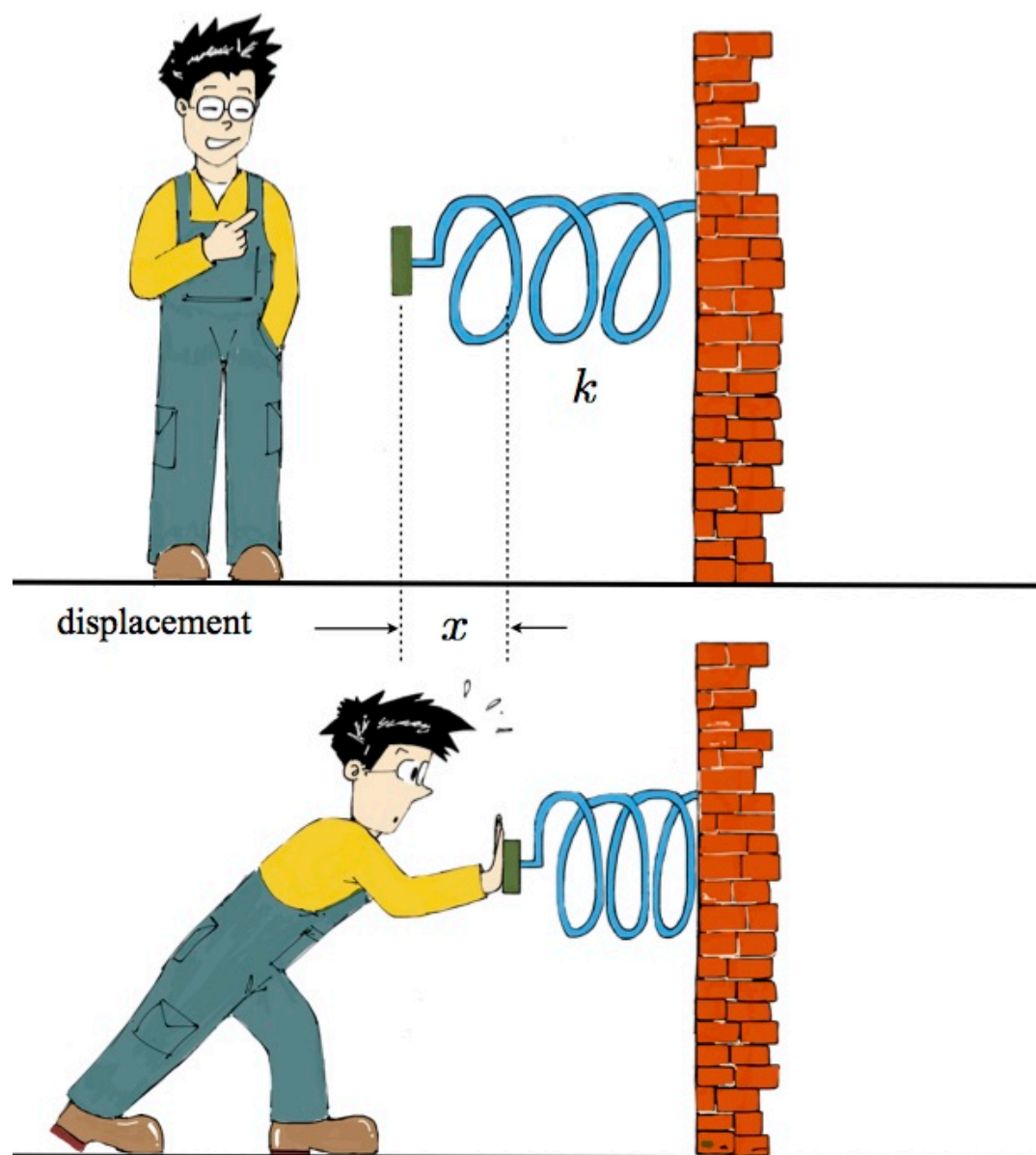


Damping constant [N.s/m]

Spring element

Any flexible element where it deforms if an external force is applied, and returns to its original shape when the force is absence.

$$F = k \times x$$



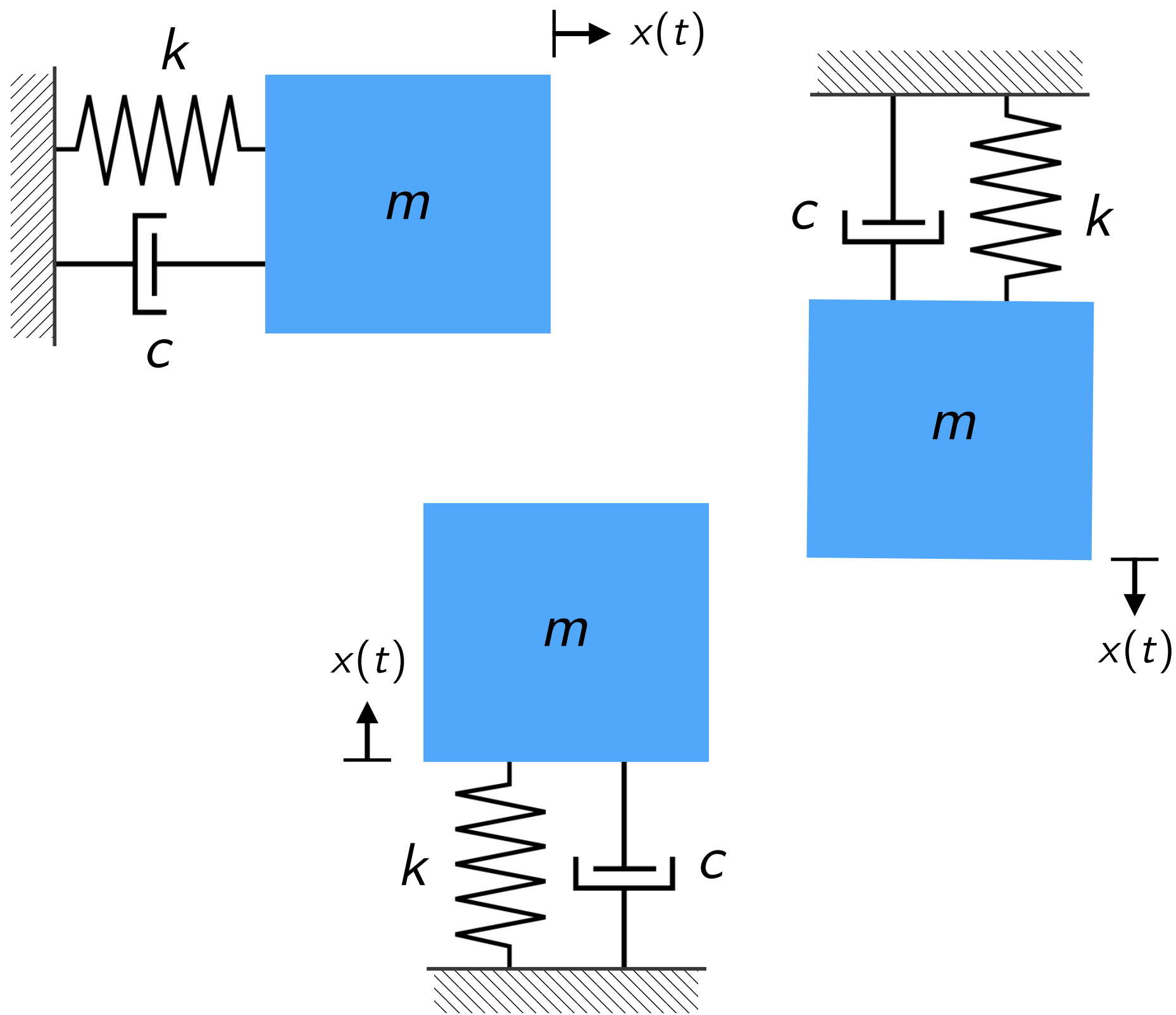
Mathematical symbol:



k

Stiffness constant [N/m]

Mass-damper-model system: Single-degree-of-freedom-system



My website:

<http://www.azmaputra.com>



My white-board animation videos:

<http://www.youtube.com/c/AzmaPutra-channel>



A. Putra, R. Ramlan, A. Y. Ismail, *Mechanical Vibration: Module 9 Teaching and Learning Series*, Penerbit UTeM, 2014

D. J. Inman, *Engineering Vibrations*, Pearson, 4th Ed. 2014

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