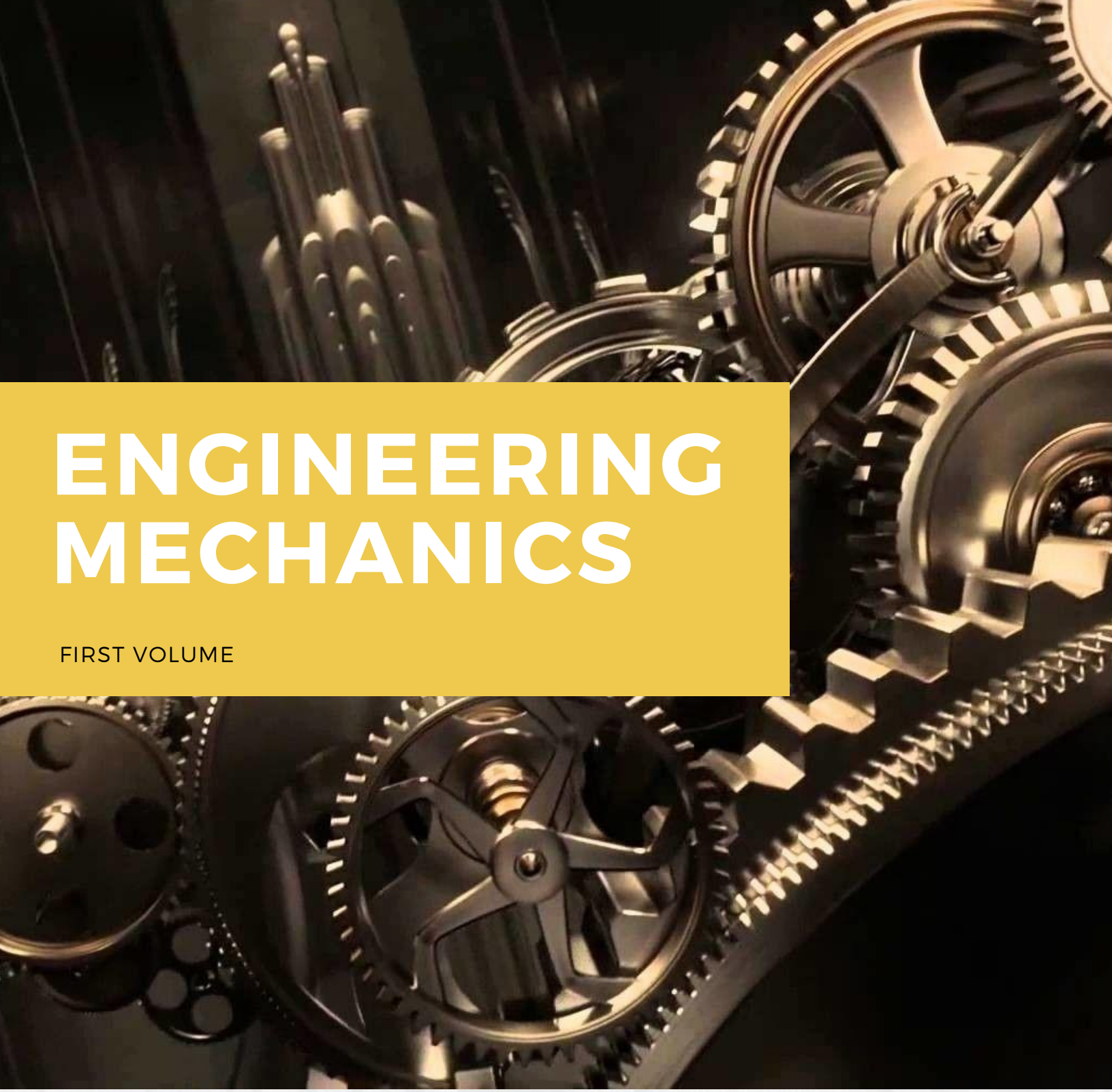

ENGINEERING MECHANICS

FIRST VOLUME

PREPARED BY

Izham Effendy Bin Ismail
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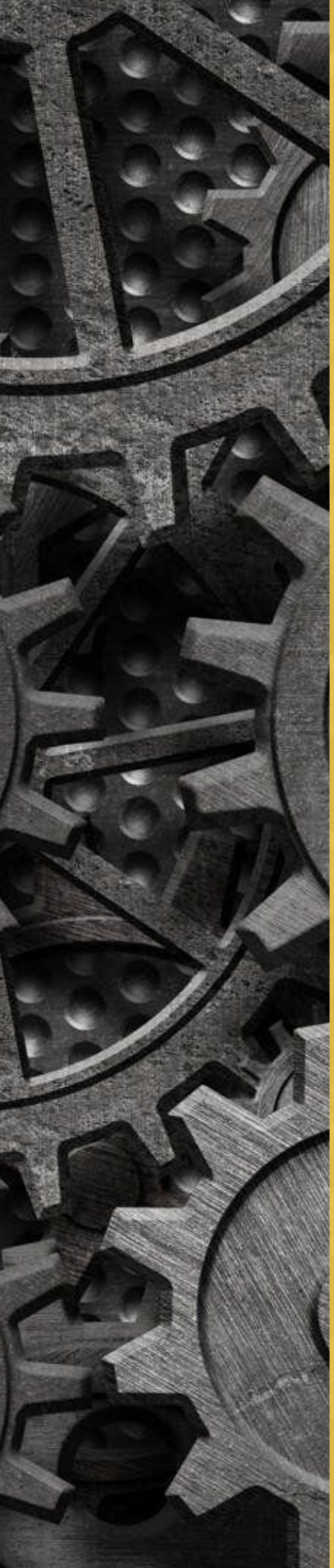
Polytechnic Nilai



KEMENTERIAN PENGAJIAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

POLITEKNIK MALAYSIA
NILAI

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PREFACE

Assalamualaikum and good day to all,

This workbook is created and developed as a Continual Quality Improvement (CQI) for Engineering Mechanics course. The Course Outcome Review Report (CORR) findings stated that course notes and in class activities should be improved and update with suitable and effective teaching method. It is also stated that students should be answered the past year questions to familiarize and improve their confident level.

It is my intention to write a book with notes and exercises to improve student's understanding and make this course easier to understand and gain a good result.

This book is the results of years of experience as an Engineering Mechanics course coordinator. It is also as a platform for my team and me to sharing the knowledge with other lecturers.

I sincerely hope this book will give you some additional knowledge and share it to others. The fact is knowledge sharing will improve our knowledge understanding and spread love with each other.

Good luck all.

IZHAM EFFENDY BIN ISMAIL
COORDINATOR
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ACKNOWLEDGMENT

We are very grateful to Allah S.W.T for giving us the opportunity to have the determination and passion to complete this book. Thank to Allah S.W.T for his Richness, that we finally complete our book after giving all our effort and time to complete it.

Firstly, we would like to express our gratitude to our dedicated Head of Department, Dr. Faraziah binti Hassan for all her commitment, advice and guidance during the completion of this book. Without her guidance and commitment, we would not be able to complete this book properly. We also like to express gratitude and proud feeling to our Program Leader, Ms Zarina binti Mohd Zin those give their cooperation and advices by the time.

We would like to thank to all my colleagues and staffs as well as students in Politeknik Nilai whose give very good cooperation in contributing ideas directly and indirectly especially staff and students in the Mechanical Engineering Department. May Allah bless them and give reward to all who assisted us to complete this book.

Finally, we wish to express gratitude to Polytechnic Nilai managements for their support morally during this book developed. Thanks a lot for all the supporters and all people that involve directly or indirectly with this book.

TABLE OF CONTENTS

BASIC KNOWLEDGE RECALLING

International System of Units (SI Units)

QUANTITY	NAME OF UNITS	SYMBOL	QUANTITY
Length	meter	m	l
Mass	kilogram	kg	m
Time	second	s	t
Electrical current	ampere	A	I
Temperature	Kelvin	K	T
Luminous intensity	candela	cd	Iv
Amount of substance	mole	mol	n

Table 1: SI Units

Prefix

PREFIX	SYMBOL	MEANING	ORDER OF MAGNITUDE
giga	G	1 000 000 000	10^{9}
mega	M	1 000 000	10^{6}
kilo	k	1 000	10^{3}
hecto	h	100	10^{2}
deka	da	10	10^{1}
	Base unit	1	10^{0}
deci	d	0.1	10^{-1}
centi	c	0.01	10^{-2}
milli	m	0.001	10^{-3}
micro	μ	0.000 001	10^{-6}
nano	n	0.000 000 001	10^{-9}

Table 2: Common Prefixes used with SI Units

EXAMPLE

1. How many centiliters (cL) are there in 61 000 milliliters (mL)?

Solution

initial prefix is “mili” = 10^{-3}
final prefix is “centi” = 10^{-2}

$(10^{-3})/(10^{-2}) = 10^{(-3)(-2)}$
$= 10^{-1}$

So, 61 000 milliliters = 60 000 x 10^{-1} centiliters or 6.1 x 10^{3} centiliters ***(Answer)***

2. Convert 3 km/h to m/s

Solution

1 km = 1000 meter
1 hour = 3600 seconds

So,

$$\frac{3km}{h} \times \frac{1000m}{1km} \times \frac{1h}{3600s} = \frac{3000m}{3600s} = 0.83m/s$$

= 0.83 ms^{-1} or 0.83 m/s ***(Answer)***

3. Solve the (100 mN) (5 GN) with SI unit having an appropriate prefix.

Solution

1 mili = 10^{-3}
1 Giga = 10^{9}
N = Load

So, 100 mN = 100 x 10^{-3} N
5 GN = 5 X 10^{9}

= (100 x 10^{-3} N) (5 x 10^{9} N)
= (100 x 5) (10^{-3} x 10^{9}) N
= (500) (10^{6}) N
= 500 X 10^{6} N ***(Answer)***

4. Kamal walking along a straight road for 5 minutes and covers 2000 meters. Find the speed in km/hr.

Solution

2000 meters = 2 km
5 minutes = 0.083 hr

So, = 24 km/hr ***(Answer)***

EXERCISES

1. How many centimeters (cm) are there in 3000 millimeters (mm)?

Hints
initial prefix is “mili” = 10^{-2}
final prefix is “centi” = 10^{-3}

(Answer: 300 cm)

2. Convert 80 km/h to m/s.

Hints
1 km = 1000 meter
1 hour = 3600 seconds

(Answer: 22.2 ms^{-1})

3. Solve the (50 MN) (3 kN) with SI unit having an appropriate prefix.

Hints
1 mega = 10^6
1 Giga = 10^3
N = Load

(Answer: $150x10^9$ N^2)

4. How many kilometers (km) are there in 500 000 millimeters (mm)?

(Answer: 0.5 km)

5. Convert 0.5 km/h to m/s.

(Answer: 0.138 ms^{-1})

6. Solve the (9000 μN) ÷ (2 kN) with SI unit having an appropriate prefix.

(Answer: 4500 x 10^{-9})

7. Convert 2000 N to kN.

(Answer: 2 kN)

8. Convert 50 kN to N.

(Answer: 50000 N)

9. How many meters (m) are there in 30000 millimeters (mm)?

(Answer: 30 mm)

10. Convert 38 km/h to m/min.

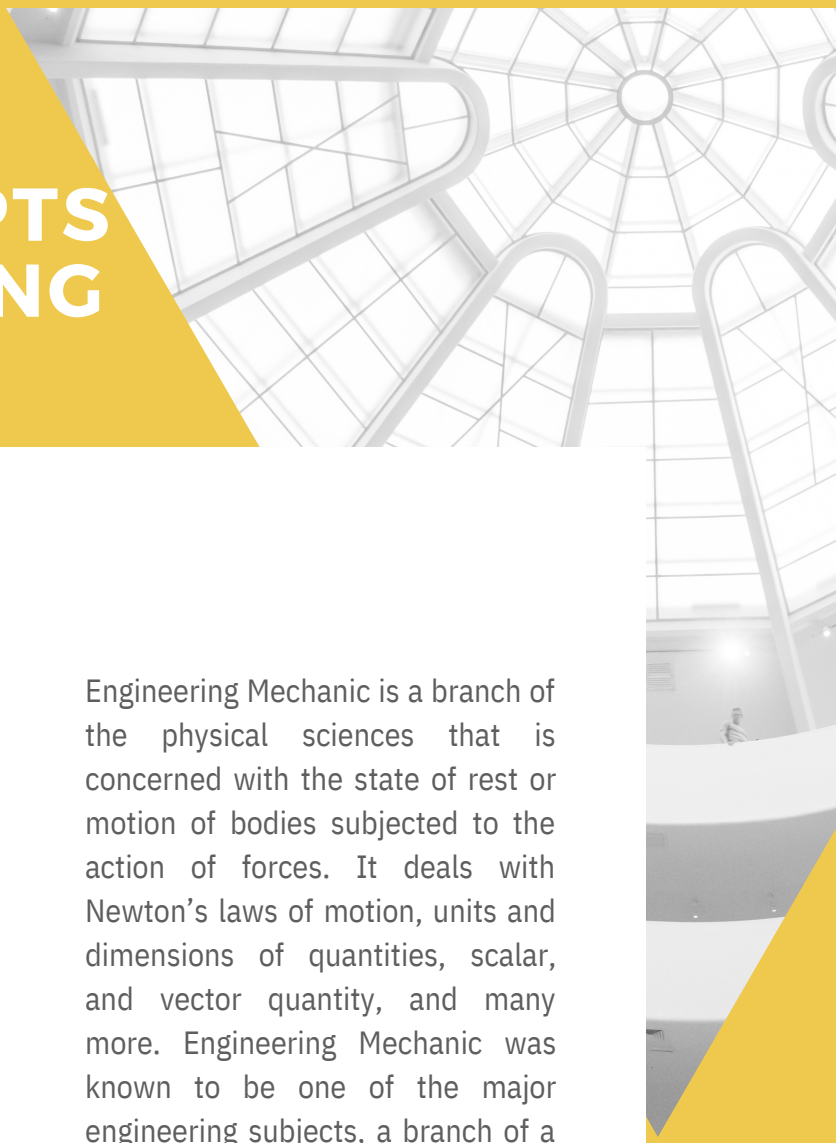
(Answer: 633.33 m/min)

11. Convert 30 000 km/h to m/s.

(Answer: 8333.33 m/s)

12. Kumala drives to the town with distance of 9 km in 20 minutes. Find the speed in km/h to arrive at the town.

(Answer: 27 km/hr)



CHAPTER 1:

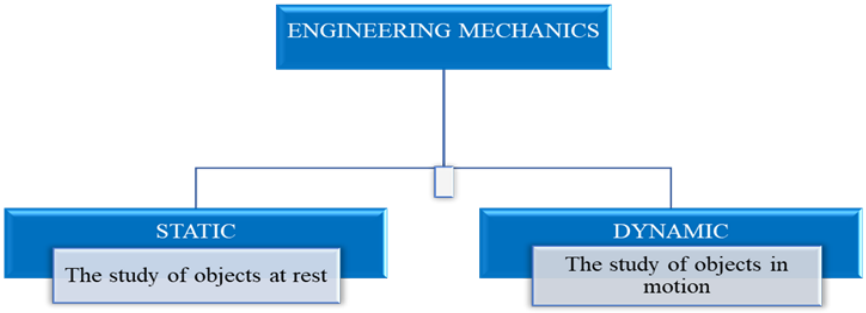
BASIC CONCEPTS OF ENGINEERING MECHANICS

1.1 Concepts of Mechanics

Engineering is the knowledge and creative application of science, mathematical methods, and empirical evidence to the innovation, design, construction, and maintenance of structures, machines, materials, devices, systems, processes, and organizations.

Mechanics is a branch of the physical sciences that is concerned with the state of rest or motion of bodies that are subjected to the action of forces.

Engineering Mechanic is a branch of the physical sciences that is concerned with the state of rest or motion of bodies subjected to the action of forces. It deals with Newton's laws of motion, units and dimensions of quantities, scalar, and vector quantity, and many more. Engineering Mechanic was known to be one of the major engineering subjects, a branch of a combination of the physical and practical application of mechanics.



Statics is primarily concerned to system of forces applied to body at rest. Even with the internal and external forces acting bodies may remain at rest.

Dynamics is concerned with moving bodies. It is subdivided into two parts as Kinematics and Kinetics. Kinematics deals with the geometry of motion without taking into consideration the loading that causes this motion. Kinetics considers the loads that cause the motion.

TERMS	DEFINITIONS
Static	Concerns the **equilibriums** of bodies under the action of forces.
Dynamics	Concerns the motion of bodies or **accelerated motion** of bodies.
Space	The **geometric region occupied** by bodies whose positions are described by linear and angular measurements relative to a coordinate system.
Particles	A particle has a mass, but a **size** that can be neglected.
Rigid Body	Considered as a combination of a large number of particles remain at a **fixed distance** from one another, both before and after applying a load.
Force	The **action** of one body on another.

Table 1.1: Definitions of basic terms in Engineering Mechanics

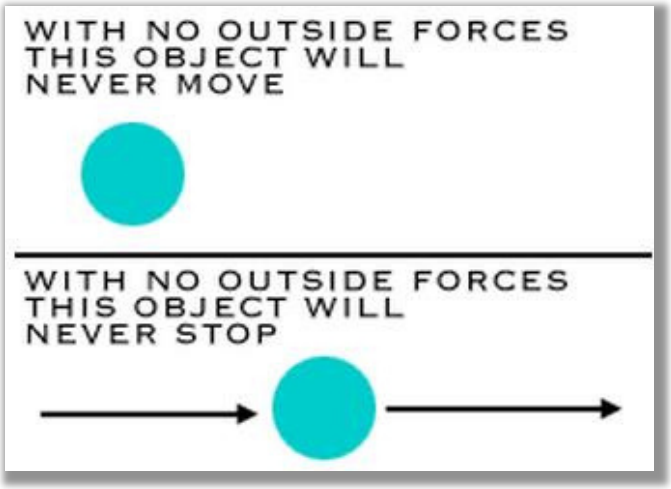
1.2 First Law of Motion

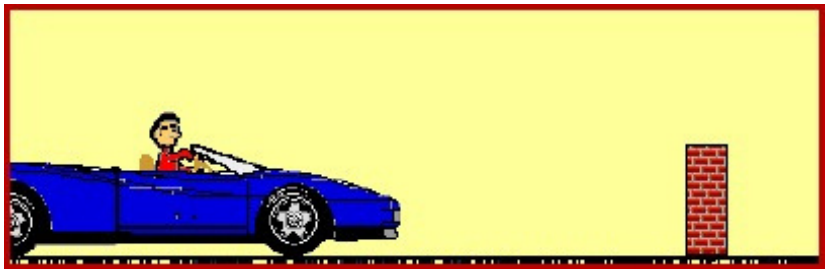
According to Newton's First Law:

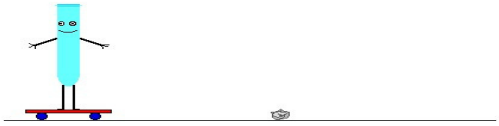
An object at rest will remain at rest unless acted on by an unbalanced force.

An object in motion continues in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

This law is also called as "the law of inertia'.



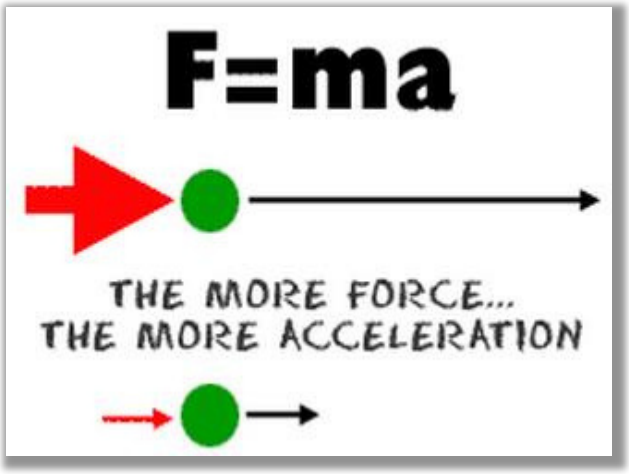


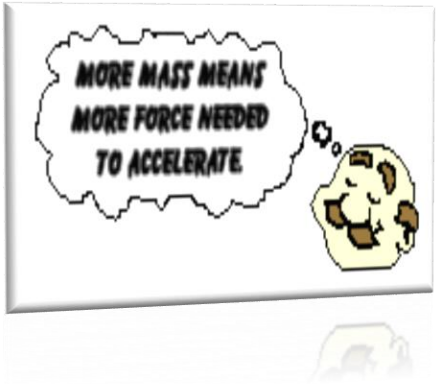


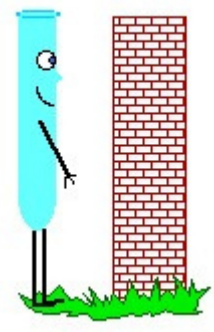
1.3 Second Law of Motion

According to Newton's Second Law:

Acceleration is produced when a force acts on a mass. The greater the mass (of the object being accelerated) the greater the amount of force needed (to accelerate the object).



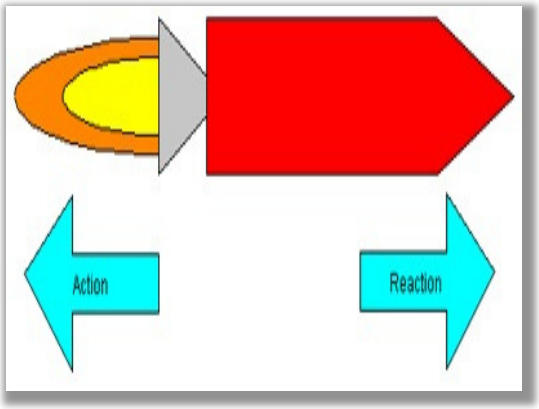


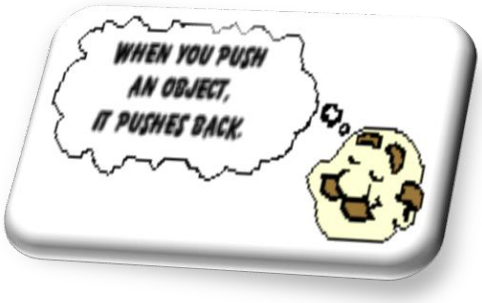


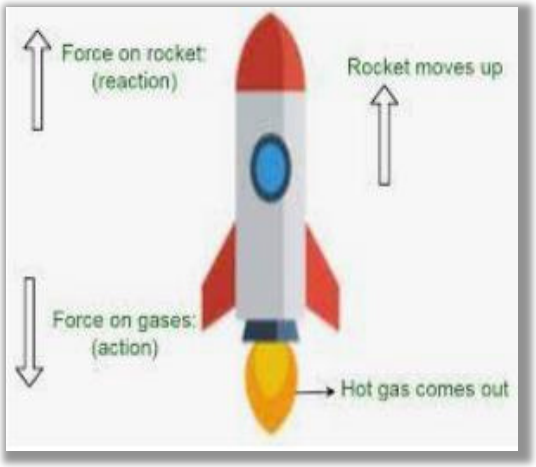
1.4 Third Law of Motion

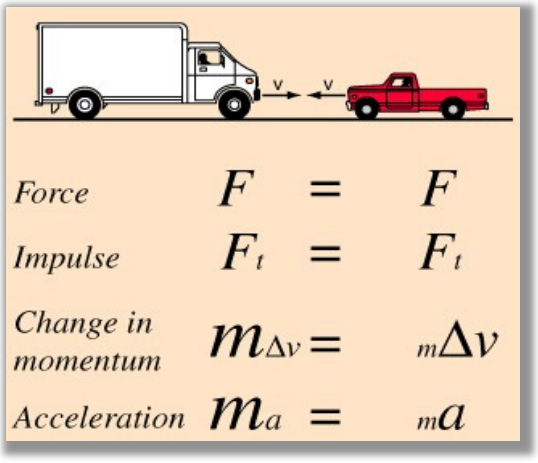
According to Newton's Third Law:

For every action there is an equal and opposite re-action, where by two bodies interact with one another, they will apply forces equal in magnitude and opposite direction.









EXAMPLE

1. Karim's car has a mass of 2000 kg is out of fuel. Karim is trying to push the car to the fuel station and makes the car move 0.5 ms^{-2}. Find the force applied to the car for that movement using Newton's Second Law.

Figure 1: Karim pushes his car

Solution

Newton's Second Law stated that F=ma, which is: F = force (N)
m = mass (kg)
a = acceleration (ms^{-2})

From the question, given m =2000 kg, a = 0.5 ms^{-2}

So, applied F = ma

= 2000 kg x 0.5 ms^{-2}

= 1000 N or 1kN ***(Answer)***

2. The most massive train at Russia in 1985 travelled 1022 km. This freight train was over 6km long and had a total mass of 9.94 x 10^6 kg. Suppose the train's acceleration from rest to an average speed of 45 km/h was 0.21 m/s^2. What would then be the size of the unbalanced force that the locomotive exerted on the cars of the train?

Figure 2: Massive train

Solution

Solution:

GIVEN:
Mass, m = 9.94 x 10^6 kg
Acceleration, a = 0.21 m/s^2
Unbalanced force, F =?

So, F = ma

F = 9.94 x 10^6 kg x 0.21 m/s^2

F = 2.0874 x 10^6 kg m/s^2 = 2.0874 x 10^6N ***(Answer)***

EXERCISES

1. Define the terms below:

a) Static

b) Dynamics

2. Define the meaning of rigid body and provide one (1) example.

3. What is the law of inertia?

4. Describe Newton's First Law and discuss one situation related to Newton’s First Law of motion with examples in everydays life.

5. Describe Newton's Second Law and discuss one situation related to Newton’s Second Law of motion with examples in everydays life.

6. Describe Newton's Third Law and discuss one situation related to Newton’s Third Law of motion with examples in everydays life.

7. Kassim car's weight of 2000 N is out of fuel. Kassim is trying to push the car to the fuel station and makes the car move 0.3 ms^{-2}. Find the force applied to the car for that movement using Newton's Second Law.

Hints:
W = mg
Given: Weight, W = 2000 N
Acceleration, a = 0.3 ms^{-2}

(Answer: 61.16 N)

8. The force of 9000 N is applied to the crate to move it from Abu's house to Aina's house. Find the acceleration of that movement if mass of the crate is 300 kg.

(Answer: 30 ms^{-2})

9. A car travels 2059 km within 48 hours. This car is 2.25 m long and has a total mass of 2.05 x 10^3 kg. Suppose the car's acceleration from rest to an average speed of 100 km/h was 0.9 m/s^2. What would then be the size of the unbalanced force that the car exerted?

(Answer: 1845 N)

10. The truck has a total mass of 20 x 10^3 kg. Suppose the truck's acceleration from rest to an average speed of 100 km/h was 2.0 m/s^{-2}. What would then be the size of the unbalanced force that the truck exerted?.

(Answer: 40 x 10^3 N)

11. If a 10 kg object is subjected to a force of 100 N, how much will it accelerate?

(Answer: 10 ms^{-2})

12. An object with mass of 8 kg and a force of 12 N applied to it. What is the resulting acceleration of the object?

(Answer: 1.5 ms^{-2})

13. A train travels 205 x 10^3 m within 36 hours. This train is 200 m long and has a total mass of 300x 10^3 kg. Suppose the train's acceleration from rest to an average speed of 120 km/h was 0.5 m/s^2. What would then be the size of the unbalanced force that the train exerted?

(Answer: 150 kN)

14. The force of 2 kN is applied to the crate to move it from Aiman's house to Zya's school. Find the acceleration of that movement if mass of the crate is 60 kg.

(Answer: 33.3 ms^{-2})

15. When a train pushes a truck with a given force, the truck is applying an equal and opposite force on the train. This statement is referred to Newton's _____ Law.

16. Newton's Third Law states that for every action there is _____.

17. Explain how Newton's Third Law of Motion applies to a system of objects.

18. Describe the phenomenon of a seat belt keeping someone restrained in their seat during a car crash.

19. The equal and opposite forces described by Newton's Third Law are called _____ and _____ forces.

20. An object will remain at rest until the _____ force act on it.

21. A table _____ move by itself because of inertia.

22. _____ is needed to move a table.

PAST YEAR QUESTIONS

1. Define the terms below. **(June 2015) [6 marks]**

   a) Static

   b) Dynamics

   c) Third Newton's Law

2. List Three basic measurements quantities. **(Dec 2015) [3 marks]**

3. Define the terms below. **(June 2016) [3 marks]**

a) Particles

b) Rigid Body

4. Explain Newton's Law of Motion below. **(June 2016) [5 marks]**

a) First Law

b) Second Law

5. Name FOUR (4) basic quantities in the field of mechanics. **(Dec 2016) [4 marks]**

6. Define the terms below. **(June 2017) [4 marks]**

a) Mass

b) Space

7. List Four (4) basic measurements quantities. **(Dec 2017) [4 marks]**

8. Explain Newton's Law of Motion below. **(Dec 2017) [5 marks]**

a) First Law

b) Second Law

9. Define the terms below. **(June 2018) [4 marks]**

a) Static

b) Dynamics

10. Define Newton's Second Law of Motion and give ONE (1) appropriate example.
(Dec 2018) [4 marks]

11. Define Newton's First Law of Motion. **(June 2019) [4 marks]**

12. Name the term of the following statements below. **(Dec 2019) [3 marks]**

a) A combination of large number of particles occupying fixed positions with respect to each other.

_____

b) The action of one body to another body. It can be exerted by actual contact or at a distance.

_____

c) The concept for measuring the succession and the duration of events or a concept for ordering the flow of event.

_____

13. Define the terms below. (**Session 1 2021/2022) [4 marks]**

a) Particles

b) Rigid body

14. Describe the Newton's Second Law of motion. **(Session 1 2021/2022) [4 marks]**

15. Name TWO (2) basic measurement quantities and the SI units.
(Session 2 2021/2022) [4 marks]

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