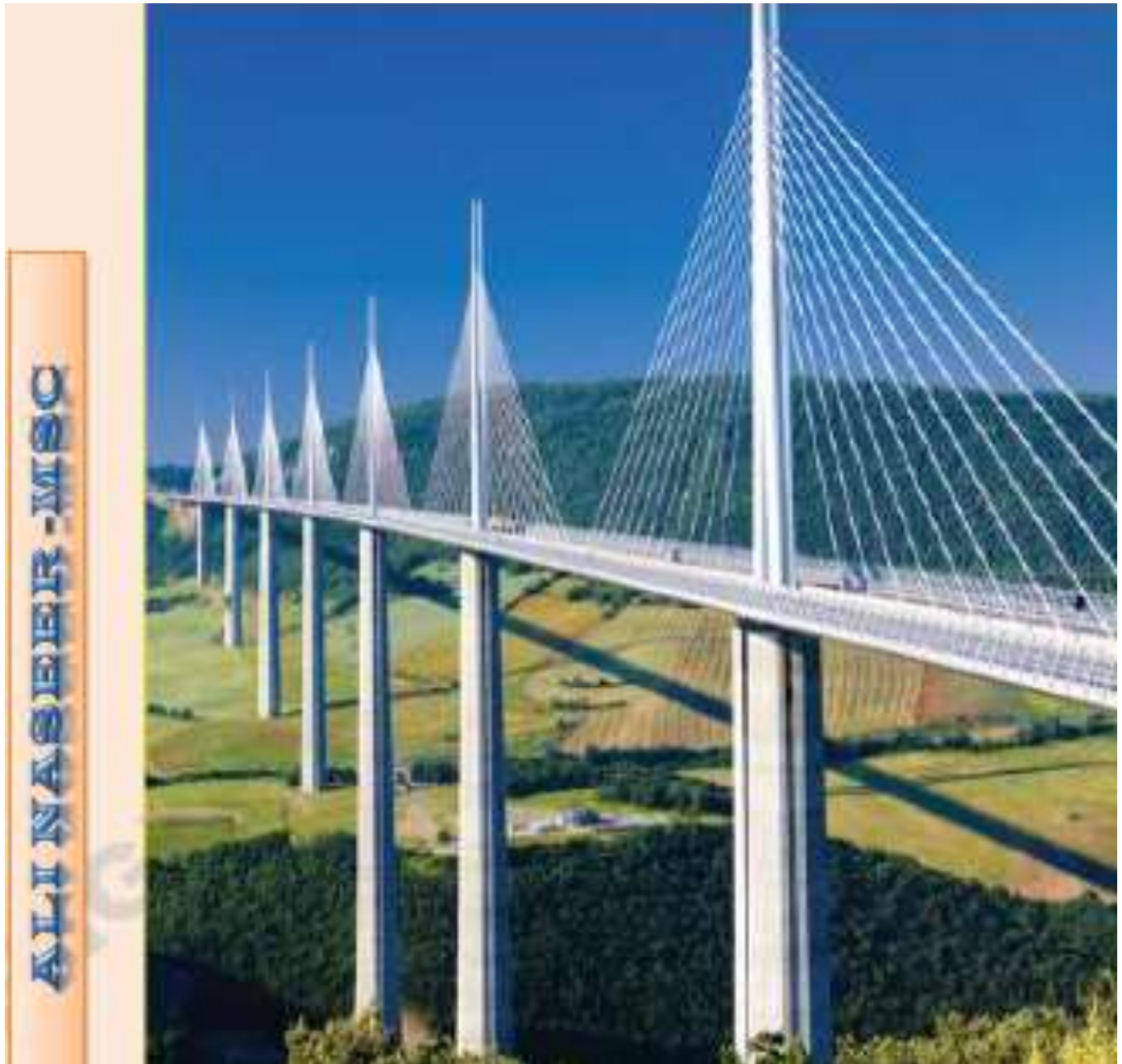


Ministry of Higher Education and Scientific Research
AL- Muthanna University
College of Engineering
Electronic and Communications Department
Course “Engineering Mechanics” (Statics)
Stage: First Year
Lectures: MSC “ Ali Nassir Hussain”



Course Number: PGE102: Engineering Mechanics (Statics)

Instructor: MSC “ Ali Nassir Hussain

Credit hours: 3 Textbook: Engineering mechanics / J.L. Meriam, L.G. Kraige.-7th ed.:

References:

J. L. Meriam and L. G. Kraige, ‘Engineering Mechanics: 7th edition,

Meriam, J. L. (James L.)

Engineering mechanics / J.L. Meriam, L.G. Kraige.-7th ed.

Course Contents:

This course covers: principles of statics, Resultant of a force system, Equilibrium of a force system, Moment of a force, Friction, centroid and center of gravity, Moment of inertia, analysis of internal forces

Grading Policy:

The final letter grade will be computed using the following criteria:

- Homework/Quizzes 5%
- Midterm Exam I 17.5%
- Midterm Exam II 17.5%
- Final Exam 60%

Contents

1. Chapter One:

- 1.1 • Review and Fundamental concepts:
- 1.2 • Fundamental concepts and units of measurement
- 1.3 • General procedure for analysis of structures

2. Chapter Two:

- 2.1 • Force vectors:
- 2.2 • Vector Operations
- 2.3 • Rectangular Components :Two Dimensional system.
- 2.4 • Rectangular Components: Three Dimensions system.
- 2.5 • Moments of a force

3. Chapter Three:

- 3.1 • Equilibrium for a Rigid Body
- 3.2 • Conditions for Rigid-Body Equilibrium
- 3.3 • Free-Body Diagrams

4. Chapter four:

- 4.1 • Structural Analysis
- 4.2 • Analysis of trusses:
- 4.3 • The Method of Joints
- 4.4 • The Method of Sections

5. Chapter Five:

- 5.5 • Frames and Machines

6 . Chapter six:

- 6.1 • Centroid:
- 6.2 • Centroid of a line in a plane:
- 6.3 • Centroid of Area:
- 6.4 • Symmetry :
- 6.5 • Centroids of Plane Areas:
- 6.6 • Centroid of composite areas:

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. In general, this subject can be subdivided into three branches: rigid-body mechanics, deformable-body mechanics, and fluid mechanics. In this semester we will study rigid-body mechanics since it is a basic requirement for the study of the mechanics of deformable bodies and the mechanics of fluids. Furthermore, rigid-body mechanics is essential for the design and analysis of many types of structural members, mechanical components, or electrical devices encountered

in engineering. Rigid-body mechanics is divided into two areas: statics and dynamics.

Statics deals with the equilibrium of bodies, that is, those that are either at rest or move with a constant velocity; Whereas:

dynamics is concerned with the accelerated motion of bodies. We can consider statics as a special case of dynamics, in which the acceleration is zero; however, statics deserves separate treatment in engineering education since many objects are designed with the intention that they remain in equilibrium.

Basic Concept.

The following concepts and definitions are basic to the study of mechanics, and they should be understood at the outset. **Force** is the action of one body on another. A force tends to move a body in the direction of its action. The action of a force is characterized by its magnitude, by the direction of its action, and by its point of application. Thus force is a vector quantity, and its properties are discussed in detail in Chapter 2. **particle** is a body of negligible dimensions. In the mathematical sense, a **particle** is a body whose dimensions are considered to be near zero so that we may analyze it as a mass concentrated at a point.

Scientific method:

- ☐ Recognize a question (unexplained fact).
- ☐ Make an educated guess (hypothesis) .
- ☐ Make prediction about the consequences of the hypothesis.
- ☐ Perform an experiment or make calculations .
- ☐ Formulate a general rule .

Fundamental concepts and units of measurement

The following four quantities are used throughout mechanics:

1. Length
2. Time
3. Mass
4. Force

Idealizations (particle) – (Concentrated Force)

TABLE 1-1 Systems of Units

Name	Length	Time	Mass	Force
International System of Units SI	meter	second	kilogram	newton*
	m	s	kg	$\frac{N}{\left(\frac{kg \cdot m}{s^2}\right)}$
U.S. Customary FPS	foot	second	slug*	pound
	ft	s	$\left(\frac{lb \cdot s^2}{ft}\right)$	lb

*Derived unit.

TABLE 1-2 Conversion Factors

Quantity	Unit of Measurement (FPS)	Equals	Unit of Measurement (SI)
Force	lb		4.448 N
Mass	slug		14.59 kg
Length	ft		0.3048 m

The International System of Units

Of the four fundamental concepts i.e length, time, mass and force, three of them length, time and mass have fundamental units. The fourth concept i.e. force has a derived unit which is based on the three fundamental units. Fundamental units also known as the basic units are arbitrarily defined and are independent of each other. In this book SI units have been extensively used. The SI unit of length is metre (m), of mass is kilogram (kg), of time is seconds (s). Derived units depend on the fundamental units. The SI unit of force is Newton (N). $1 N = 1 kg m/s^2$.

The SI units used in mechanics are listed below.

Quantity	SI Unit	Formula	Symbol
Length	Metre	Basic Unit	m
Mass	Kilogram	Basic Unit	kg
Time	Second	Basic Unit	s
Acceleration	Metre per second square	m/s^2	-
Angle	Radian	-	rad
Angular Acceleration	Radian per second square	rad/s^2	-
Angular Velocity	Radian per second	rad/s	-
Area	Square metre	m^2	-
Couple	Newton-metre	N.m	-
Density	Kilogram per cubic metre	kg/m^3	-
Energy	Joule	N.m	J
Force	Newton	$kg.m/s^2$	N
Frequency	Hertz	s^{-1}	Hz
Impulse	Newton-second	$kg.m/s$	-
Moment of force	Newton-metre	N.m	-
Power	Watt	J/s	W
Pressure	Pascal	N/m^2	Pa
Stress	Pascal	N/m^2	Pa
Velocity	Meter per second	m/s	-
Volume of solids	Cubic metre	m^3	-
Volume of liquids	Litre	$10^{-3} m^3$	L
Work	Joule	N.m	J

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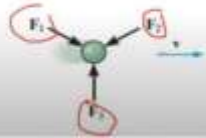
Newton's Laws of Motion

قوانين نيوتن للحركة

First Law

A particle originally at rest, or moving in a straight line with constant velocity, tends to remain in this state provided the particle is not subjected to an unbalanced force

يظل الجسم على حالته الحركية (إما السكون التام أو الحركة في خط مستقيم بسرعة ثابتة) ما لم تؤثر عليه قوة تغيره من هذه الحالة



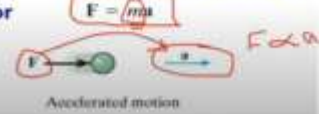
Newton's Laws of Motion

قوانين نيوتن للحركة

Second Law

A particle acted upon by an unbalanced force F experiences an acceleration a that has the same direction as the force and a magnitude that is directly proportional to the force. The proportional factor is the particle of mass m

إذا أثرت قوة أو مجموعة قوى على جسم ما فإنها تكسبه تسارعاً في اتجاهها يتناسب مع محصلة القوى المؤثرة، ومعامل التناسب هو كتلة القصور الذاتي للجسم



Accelerated motion

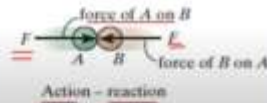
Newton's Laws of Motion

قوانين نيوتن للحركة

Third Law

For every action there is an equal and opposite reaction

لكل قوة فعل قوة رد فعل، مساوي له في المقدار ومضاد له في الاتجاه



Newton's Laws of Motion

قوانين نيوتن للحركة

Law of Gravitational Attraction

قانون الجذب الكوني

F = force of gravitation between the two particles
 G = universal constant of gravitation; according to experimental evidence, $G = 6.67 \times 10^{-11} \text{ m}^3 / (\text{kg} \cdot \text{s}^2)$
 m_1, m_2 = mass of each of the two particles
 r = distance between the two particles



$$F = F_2 = G \frac{m_1 \times m_2}{r^2}$$

1.2. General procedure for analysis

- ✓ Read the problem carefully and try to correlate the actual physical situation with the theory studied.
- ✓ Tabulate the problem data and draw to a large scale any necessary diagrams.
- ✓ Apply the relevant principles, generally in mathematical form. When writing any equations, be sure they are dimensionally homogeneous.
- ✓ Solve the necessary equations, and report the answer with no more than three significant figures.
- ✓ Study the answer with technical judgment and common sense to determine whether or not it seems reasonable

Example:

Convert 2 km/h to m/s. How many ft /s is this?

Solution:

Since 1 km = 1000 m and 1 h = 3600 s, the factors of conversion are arranged in the following order, so that a cancellation of the units can be applied:

$$\frac{2 \text{ km}}{\text{h}} = \frac{2 \cancel{\text{km}}}{\cancel{\text{h}}} \left(\frac{1000 \text{ m}}{\cancel{\text{km}}} \right) \left(\frac{1 \cancel{\text{h}}}{3600 \text{ s}} \right) = \frac{2000 \text{ m}}{3600 \text{ s}} = 0.556 \text{ m/s}$$

From Table 1-2, 1 ft = 0.3048 m. Thus,

$$0.556 \frac{\text{m}}{\text{s}} = 0.556 \frac{\cancel{\text{m}}}{\cancel{\text{s}}} \left(\frac{1 \text{ ft}}{0.3048 \cancel{\text{m}}} \right) = 1.82 \text{ ft/s}$$

What is Mechanics

ما هي الميكانيكا

Mechanics الميكانيكا

Dynamic

الديناميكا

concerns the motion of bodies

يركز على حركة الأجسام

Galileo (1564-1642)
Newton (1624-1727)

Static

الاستاتيكا

concerns the equilibrium of bodies under the action of forces

يركز على اتزان الأجسام تحت تأثير القوى

Archimedes (287-212 B.C.)
Stevinus (1548-1642)

Basic Concepts

مفاهيم أساسية

Mechanics الميكانيكا

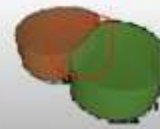
Fluid mechanics

ميكانيكا الموائع



Deformable-body mechanics

ميكانيكا الأجسام المتشكلة



Rigid body mechanics

ميكانيكا الأجسام الجاسنة



Example 1.2 :

مثال (٢.١) :

Convert the quantities 300 lb/s and 52 slug/ft³ to appropriate SI units ?
قم بتحويل القيم ٣٠٠ رطل/ث و ٥٢ سلاج / (قدم)^٣ إلى الوحدات الدولية ؟

Solution :

الحل :

$$300 \text{ lb/s} = \frac{300 \text{ lb}}{\text{s}} \left(\frac{4.448 \text{ N}}{1 \text{ lb}} \right) = 1334.5 \text{ N/s} = 1.33 \text{ kN/s}$$

$$52 \text{ slug/ft}^3 = \frac{52 \text{ slug}}{\text{ft}^3} \left(\frac{14.59 \text{ kg}}{1 \text{ slug}} \right) \left(\frac{1 \text{ ft}}{0.3048 \text{ m}} \right)^3$$

$$= 26.8 (10^3) \text{ kg/m}^3 = 26.8 \text{ Mg/m}^3$$

Example 1.3 :

مثال (٣.١) :

Evaluate each of the following and express with SI units having an appropriate prefix:

قم بتبسيط الحسابات التالية :

- (أ) (٥٠ ملي نيوتن) (٦ جيجا نيوتن)
(ب) (٤٠٠ ملي متر) (٠.٦ ميغا نيوتن)^٢
(ج) (٤٥ ميغا نيوتن)^٣ / (٩٠٠ جيجا جرام)

- (a) (50 mN)(6 GN),
(b) (400 mm)(0.6 MN)²,
(c) 45 MN³ / 900 Gg

Solution :

الحل :

$$(a) (50 \text{ mN})(6 \text{ GN}) = [50 (10^{-3}) \text{ N}][6 (10^9) \text{ N}]$$

$$= 300 (10^6) \text{ N}^2$$

$$= 300 (10^6) \text{ N}^2 \left(\frac{1 \text{ kN}}{1000 \text{ N}} \right)^2 = 300 \text{ kN}^2$$

$\text{kN}^2 = (\text{kN})^2$

$$(b) (400 \text{ mm})(0.6 \text{ MN})^2 = [400 (10^{-3}) \text{ m}][0.6 (10^6) \text{ N}]^2$$

$$= [400 (10^{-3}) \text{ m}][0.36 (10^{12}) \text{ N}^2]$$

$$= 144 (10^9) \text{ m.N}^2$$

$$= 144 \text{ Gm.N}^2$$

$$= 144 (10^9) \text{ m.N}^2 \left(\frac{1 \text{ MN}^2}{10^6 \text{ N}^2} \right)^2$$

$$= 0.144 \text{ m.MN}^2$$

$$(c) 45 \text{ MN}^3 / 900 \text{ Gg} = \frac{45 \text{ MN}^3}{900 \text{ Gg}} = \frac{45 [(10^6) \text{ N}]^3}{900 (10^6) \text{ kg}}$$

$$= 50 (10^9) \text{ N}^3 / \text{kg} \left(\frac{1 \text{ kN}}{10^3 \text{ N}} \right)^3$$