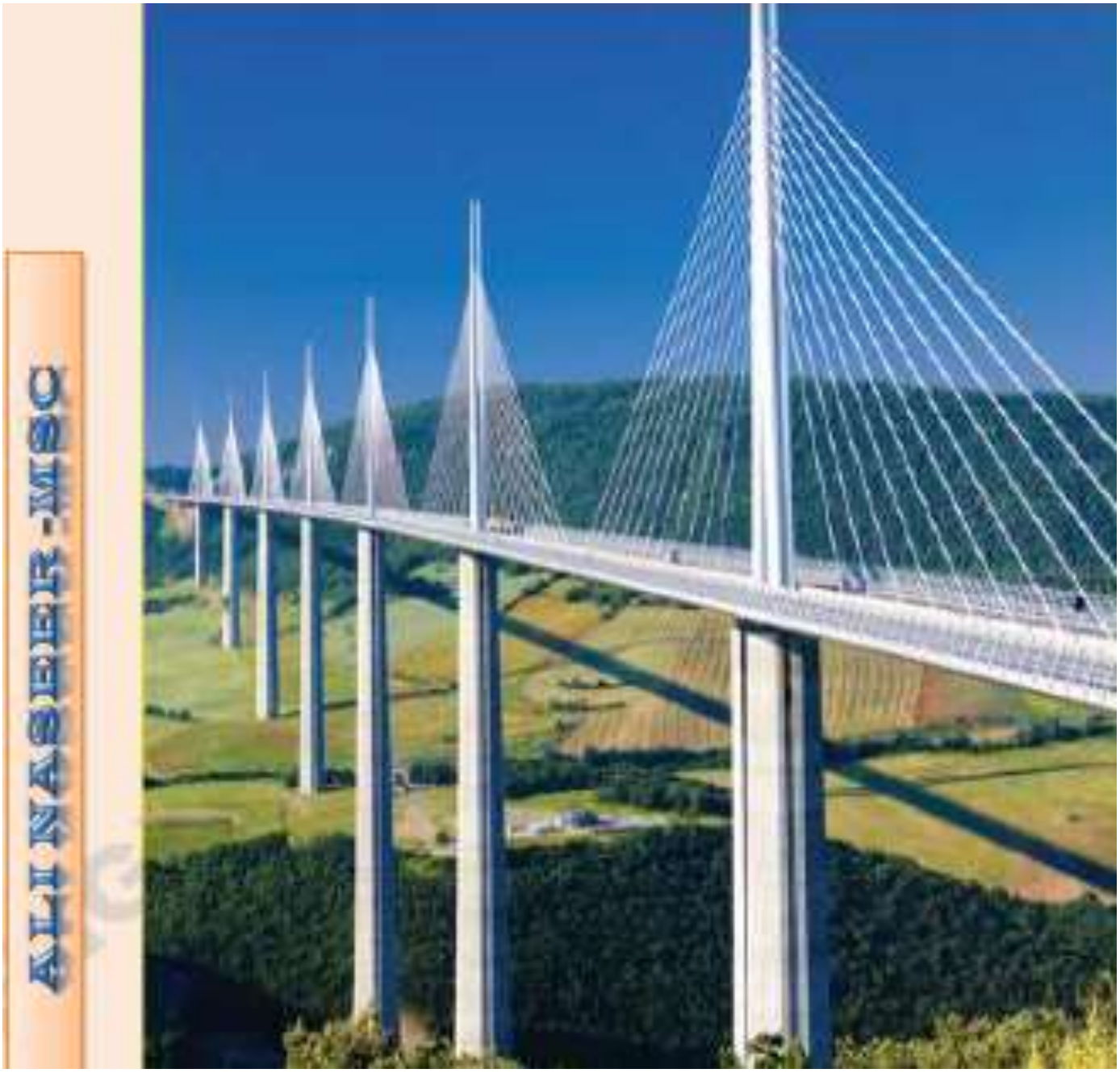
Ministry of Higher Education and Scientific Research
AL- Muthanna University
College of Engineering
Electronic and Communications Department
Course "Engineering Mechanics" (Statics)
Stage: First Year
Lectures: MSC " Ali Nassir Hussain"



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:

1.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

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 m	second s	kilogram kg	newton* N $\left(\frac{kg \cdot m}{s^2}\right)$
U.S. Customary FPS	foot ft	second s	slug* $\left(\frac{lb \cdot s^2}{ft}\right)$	pound 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/s².

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

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:

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

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

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

What is Mechanics — ما هي الميكانيكا

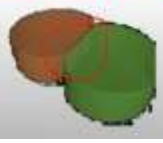
Mechanics الميكانيكا

Dynamic الديناميكا	**Static** الاستاتيكا
concerns the motion of bodies	concerns the equilibrium of bodies under the action of forces
يركز على حركة الأجسام	يركز على اتزان الأجسام تحت تأثير القوى
Galileo (1564-1642) Newton (1624-1727)	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 الجاسئة


Example 1.2 : مثال (٢.١) :

Convert the quantities 300 lb/s and 52 slug/ft^3 to appropriate SI units ?

قم بتحويل القيم ٣٠٠ رطل/ث و ٥٢ سلج /(قدم)٣ إلى الوحدات الدولية ؟

Solution : الحـــل :

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

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

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

Example 1.3 : مثال (٣.١) :

Evaluate each of the following and express with SI units having an appropriate prefix:
(a) (50 mN)(6 GN),
(b) (400 mm)(0.6 MN)^2,
(c) 45 MN^3 / 900 Gg

قم بتبسيط الحسابات التالية :
(أ) (٥٠ ملي نيوتن)(٦ جيجا نيوتن)
(ب) (٤٠٠ ملي متر) (٠,٦ ميجا نيوتن)^2
(ج) ٤٥ ميجا نيوتن ^{3}/ ٩٠٠ جيجا جرام

Solution : الحـــل :

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

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

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

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

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

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

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

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

0