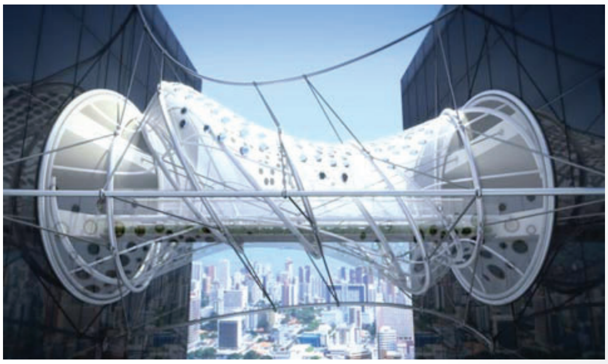
STATICS

- Vector Mechanics for Engineers: Statics, 9th edition. Ferdinand Beer- E. Russell Johnston Jr. - Phillip Cornwell.
- Engineering Mechanics-Statics, 5th Edition. J. L. Meriam, L. G. Kraige.
- Other Reference: Brain P.Self "Lectures notes on Statics"



Introduction

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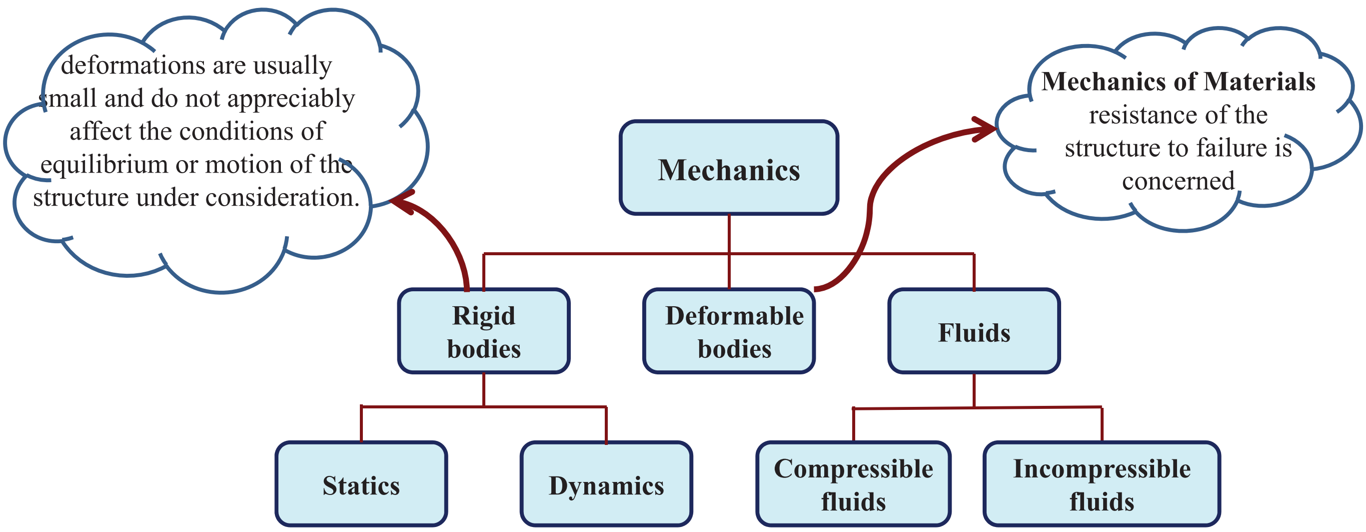
Introduction

❑ What is Mechanics?

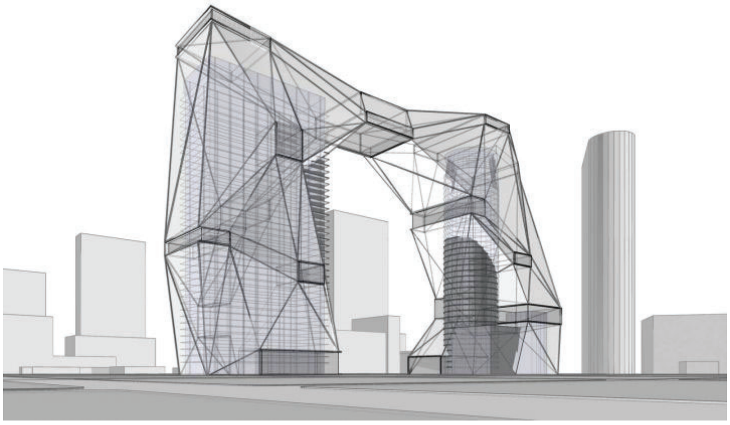
Mechanics* : *is the science which describes and predicts the conditions of rest or motion of bodies under the action of forces.



Introduction

❑ What is Mechanics?

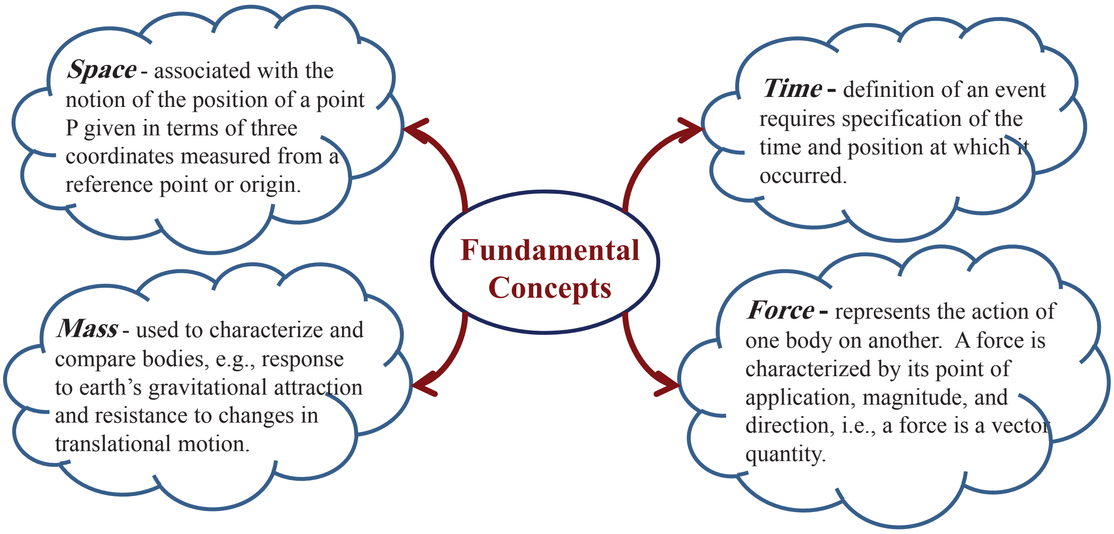
Mechanics is the ***foundation*** of most engineering sciences and is an indispensable ***prerequisite*** to their study.



Mechanics is an ***applied science*** - it is not an abstract or pure science but does not have the empiricism found in other engineering sciences.

Introduction

❑ Fundamental Concepts



In Newtonian Mechanics, space, time, and mass are absolute concepts, independent of each other. Force, however, is not independent of the other three. The force acting on a body is related to the mass of the body and the variation of its velocity with time.

In Relativistic Mechanics, where the time of an event depends upon its position, and where the mass of a body varies with its velocity.

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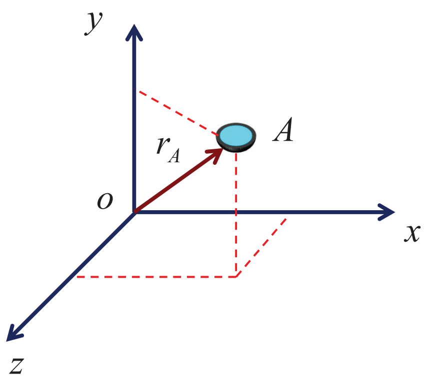
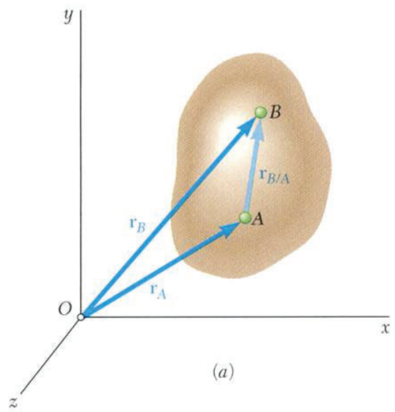
❑ Fundamental Concepts

In Newtonian Mechanics : You will study the conditions of rest or motion of ***particles*** and ***rigid bodies*** in terms of the four basic concept we have introduced.

Particle is a very small amount of matter which may be assumed to occupy a single point in space.



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



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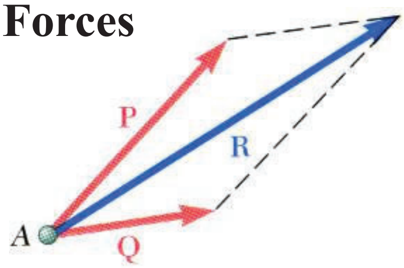
❑ Fundamental Principles

1) The Parallelogram Law for the Addition of Forces

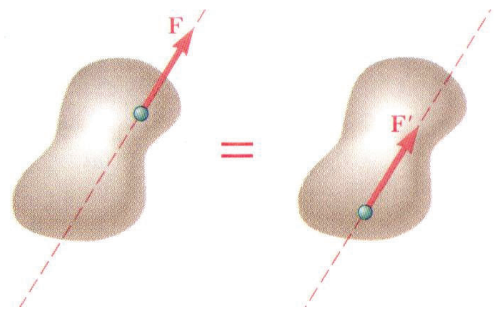
This states that two forces acting on a particle may be replaced by a single force, called their ***resultant***, obtained by drawing the diagonal of the parallelogram which bas sides equal to the given forces



• *Parallelogram Law*

2) The Principle of Transmissibility

This states that the conditions of equilibrium or of motion of a rigid body will remain unchanged if a force acting at a given point of the rigid body is replaced by a force of the same magnitude and same direction, but acting at a different point, provided that the two forces have the same line of action.



• *Principle of Transmissibility*

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❑ Fundamental Principles

3) Newton's First Law

If the resultant force on a particle is zero, the particle will remain at rest or continue to move in a straight line.

4) Newton's Second Law

A particle will have an acceleration proportional to a nonzero resultant applied force.

$$\vec{F} = m\vec{a}$$

5) Newton's Third Law

The forces of action and reaction between two particles have the same magnitude and line of action with opposite sense.

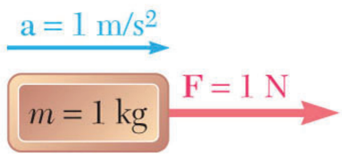
6) Newton's Law of Gravitation

Two particles are attracted with equal and opposite forces,

$$F = G\frac{Mm}{r^2} \quad , \quad W = mg \quad , \quad g = \frac{GM}{R^2}$$

Introduction

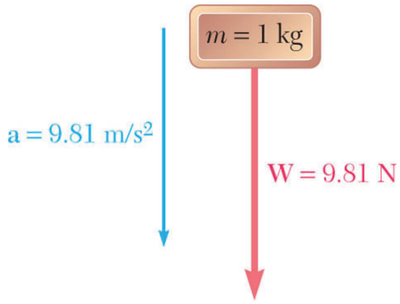
❑ Systems of Units



Length	Time	Mass	Force

Three base units may be chosen arbitrarily

The fourth must be compatible with Newton's 2nd Law.



- ***International System of Units (SI Units):*** In this system, the base units are the units of length, mass, and time, and are called, respectively, the meter (m), the kilogram (kg), and the second (s). The unit of force is called the newton (N) and is defined as the force which gives an acceleration of 1 m/ s^2 to a mass of 1 kg.

$$1\,\text{N} = (1\,\text{kg})\left(1\frac{\text{m}}{\text{s}^2}\right) = 1\frac{\text{kg}\cdot\text{m}}{\text{s}^2}$$

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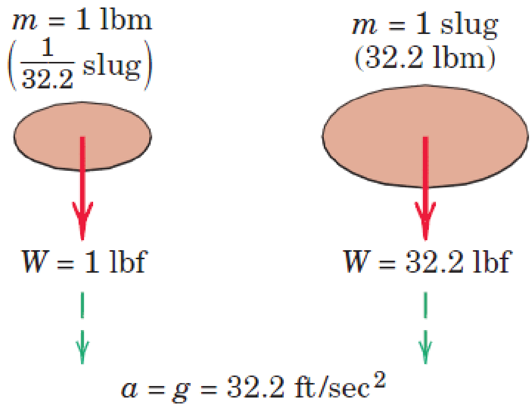
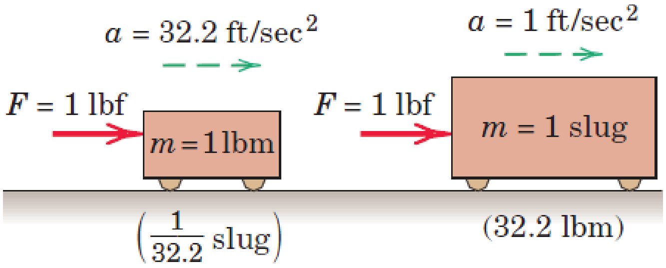
❑ Systems of Units

U.S. Customary Units: The base units are the units of length, force, and time. These units are, respectively, the foot (ft), the pound (lbf), and the second (s). The pound is defined as the weight of a platinum standard, called the standard pound, which is kept at the National Institute of Standards and Technology outside Washington and the mass of which is 0.45359243 kg.





$$1\,\text{slug} = \frac{1\,\text{lbf}}{1\,\text{ft}/\text{s}^2} = 1\frac{\text{lbf}\cdot\text{s}^2}{\text{ft}}$$

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❑ Method of Problem Solution

- ***Problem Statement*** :
  Includes given data, specification of what is to be determined, and a figure showing all quantities involved.

- ***Free-Body Diagrams*** **:**
  Create separate diagrams for each of the bodies involved with a clear indication of all forces acting on each body.

- ***Fundamental Principles*** **:**
  The six fundamental principles are applied to express the conditions of rest or motion of each body. The rules of algebra are applied to solve the equations for the unknown quantities.

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❑ Method of Problem Solution

Solution Check:

- Test for errors in reasoning by verifying that the units of the computed results are correct,

- Test for errors in computation by substituting given data and computed results into previously unused equations based on the six principles,

- always apply experience and physical intuition to assess whether results seem “reasonable”

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❑ Numerical Accuracy

- The accuracy of a solution depends on 1) accuracy of the given data, and 2) accuracy of the computations performed. The solution cannot be more accurate than the less accurate of these two.

- The use of hand calculators and computers generally makes the accuracy of the computations much greater than the accuracy of the data. Hence, the solution accuracy is usually limited by the data accuracy.

- As a general rule for engineering problems, the data are seldom known with an accuracy greater than 0.2%. Therefore, it is usually appropriate to record parameters beginning with “1” with four digits and with three digits in all other cases, i.e., 40.2 lb and 15.58 lb.

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- ❑ **Application of Statics**

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❑ UNITS CONVERSION TABLES

Table 1: Multiples and Submultiples of SI units

Prefix	Symbol	Multiplying Factor	
exa	E	10^{18}	1 000 000 000 000 000 000
peta	P	10^{15}	1 000 000 000 000 000
tera	T	10^{12}	1 000 000 000 000
giga	G	10^{9}	1 000 000 000
mega	M	10^{6}	1 000 000
kilo	k	10^{3}	1 000
hecto*	h	10^{2}	100
deca*	da	10	10
deci*	d	10^{-1}	0.1
centi	c	10^{-2}	0.01
milli	m	10^{-3}	0.001
micro	u	10^{-6}	0.000 001
nano	n	10^{-9}	0.000 000 001
pico	p	10^{-12}	0.000 000 000 001
femto	f	10^{-15}	0.000 000 000 000 001
atto	a	10^{-18}	0.000 000 000 000 000 001

* these prefixes are not normally used

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❑ UNITS CONVERSION TABLES

Table 2: Length Units

Millimeters	Centimeters	Meters	Kilometers	Inches	Feet	Yards	Miles
mm	cm	m	km	in	ft	yd	mi
1	0.1	0.001	0.000001	0.03937	0.003281	0.001094	6.21e-07
10	1	0.01	0.00001	0.393701	0.032808	0.010936	0.000006
1000	100	1	0.001	39.37008	3.28084	1.093613	0.000621
1000000	100000	1000	1	39370.08	3280.84	1093.613	0.621371
25.4	2.54	0.0254	0.000025	1	0.083333	0.027778	0.000016
304.8	30.48	0.3048	0.000305	12	1	0.333333	0.000189
914.4	91.44	0.9144	0.000914	36	3	1	0.000568
1609344	160934.4	1609.344	1.609344	63360	5280	1760	1

Table 3: Area Units

Millimeter square	Centimeter square	Meter square	Inch square	Foot square	Yard square
mm^2	cm^2	m^2	in^2	ft^2	yd^2
1	0.01	0.000001	0.00155	0.000011	0.000001
100	1	0.0001	0.155	0.001076	0.00012
1000000	10000	1	1550.003	10.76391	1.19599
645.16	6.4516	0.000645	1	0.006944	0.000772
92903	929.0304	0.092903	144	1	0.111111
836127	8361.274	0.836127	1296	9	1

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❑ UNITS CONVERSION TABLES

Table 4: Volume Units

Centimeter cube	Meter cube	Liter	Inch cube	Foot cube	US gallons	Imperial gallons	US barrel (oil)
cm^3	m^3	ltr	in^3	ft^3	US gal	Imp. gal	US brl
1	0.000001	0.001	0.061024	0.000035	0.000264	0.00022	0.000006
1000000	1	1000	61024	35	264	220	6.29
1000	0.001	1	61	0.035	0.264201	0.22	0.00629
16.4	0.000016	0.016387	1	0.000579	0.004329	0.003605	0.000103
28317	0.028317	28.31685	1728	1	7.481333	6.229712	0.178127
3785	0.003785	3.79	231	0.13	1	0.832701	0.02381
4545	0.004545	4.55	277	0.16	1.20	1	0.028593
158970	0.15897	159	9701	6	42	35	1

Table 5: Mass Units

Grams	Kilograms	Metric tonnes	Short ton	Long ton	Pounds	Ounces
g	kg	tonne	shton	Lton	lb	oz
1	0.001	0.000001	0.000001	9.84e-07	0.002205	0.035273
1000	1	0.001	0.001102	0.000984	2.204586	35.27337
1000000	1000	1	1.102293	0.984252	2204.586	35273.37
907200	907.2	0.9072	1	0.892913	2000	32000
1016000	1016	1.016	1.119929	1	2239.859	35837.74
453.6	0.4536	0.000454	0.0005	0.000446	1	16
28	0.02835	0.000028	0.000031	0.000028	0.0625	1

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❑ UNITS CONVERSION TABLES

Table 10: High Pressure Units

Bar	Pound/square inch	Kilopascal	Megapascal	Kilogram force/ centimeter square	Millimeter of mercury	Atmospheres
bar	psi	kPa	MPa	kgf/cm^2	mm Hg	atm
1	14.50326	100	0.1	1.01968	750.0188	0.987167
0.06895	1	6.895	0.006895	0.070307	51.71379	0.068065
0.01	0.1450	1	0.001	0.01020	7.5002	0.00987
10	145.03	1000	1	10.197	7500.2	9.8717
0.9807	14.22335	98.07	0.09807	1	735.5434	0.968115
0.001333	0.019337	0.13333	0.000133	0.00136	1	0.001316
1.013	14.69181	101.3	0.1013	1.032936	759.769	1

Table 16: Temperature Conversion Formulas

Degree Celsius (°C)	(°F - 32) x 5/9
	(K - 273.15)
Degree Fahrenheit (°F)	(°C x 9/5) + 32
	(1.8 x K) - 459.67
Kelvin (K)	(°C + 273.15)
	(°F + 459.67) ÷ 1.8