



# GNG 1105 Engineering Mechanics Introduction

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# Agenda



1. *What is Mechanics*
2. *Fundamental Concepts & Principles*
3. *Systems of Units*
4. *Conversion from one system to another*
5. *Method of Problem Solution*
6. *Numerical Accuracy*

# Agenda

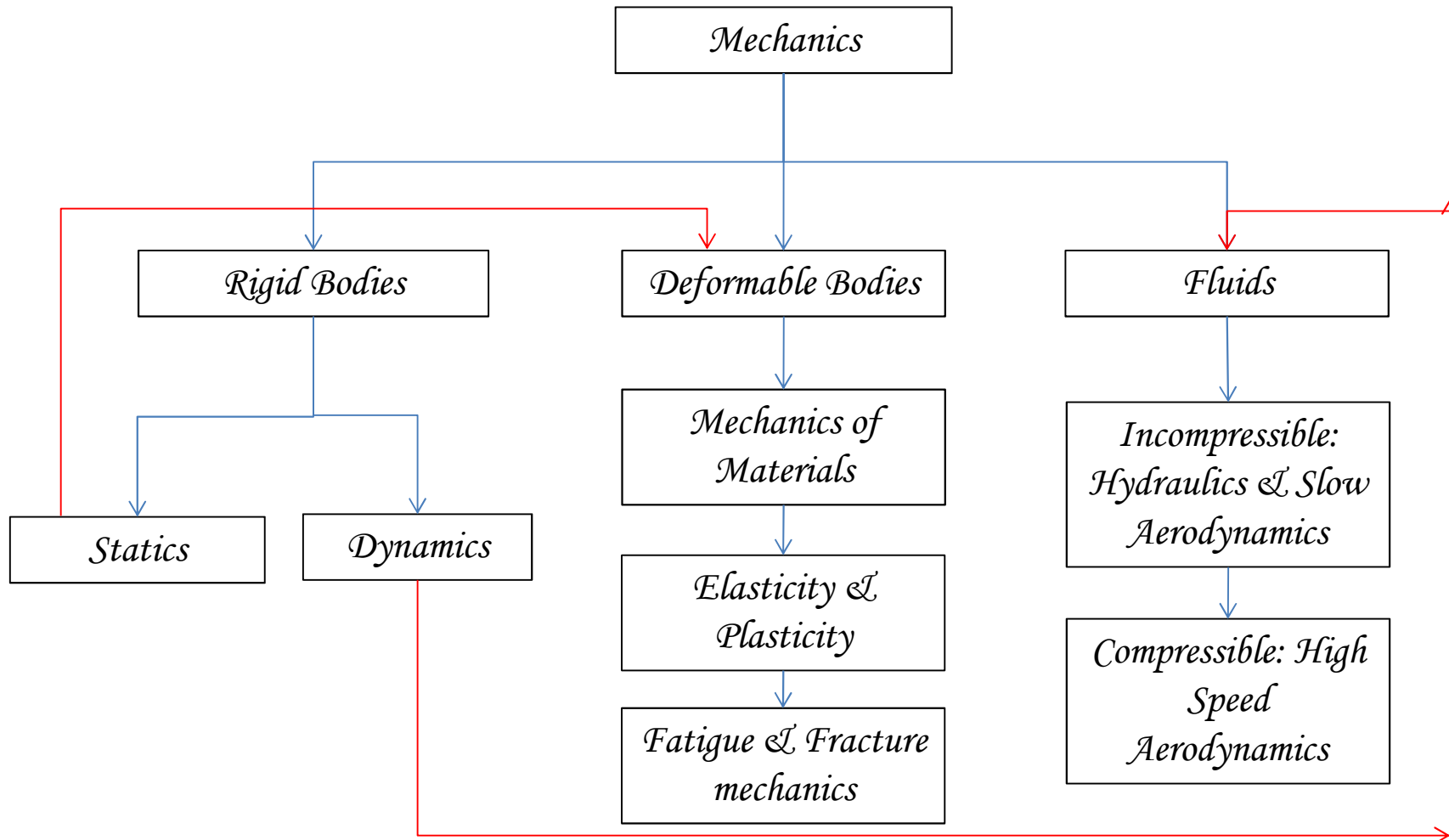


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# Definitions

- *Science which modelise the conditions of motion of bodies under the action of forces*
- *Physical Science*
- *Applied Sciences not a pure abstraction*
- *Foundation of most Engineering Sciences, therefore a prerequisite*

# Definitions



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# Fundamental Concepts & Principles

## ➤ *History*

### ➤ *Statics:*

➤ *Egyptians :Imhotep Pyramid of Pharaoh Zoser (3<sup>rd</sup> dynasty) ((2790 to 2694BC) at Sakḥara - Empirical knowledge ?*

➤ *Greeks: Archimedes (287 to 212 BC) Beginning of theoretical statics with Momentum , Center of Gravity and Lever.*



# Fundamental Concepts & Principles (Cont'd)

## ➤ *History (cont'd)*

### ➤ *Dynamics:*

#### ➤ *Galileo (1564-1642):*

- *Study of uniformly accelerated Motion*
- *Parabolic trajectory*

#### ➤ *Newton (1643-1727):*

- *Theory of Newtonians mechanics or Classic Mechanics. (Mass is invariant)*



# Fundamental Concepts & Principles (Cont'd)

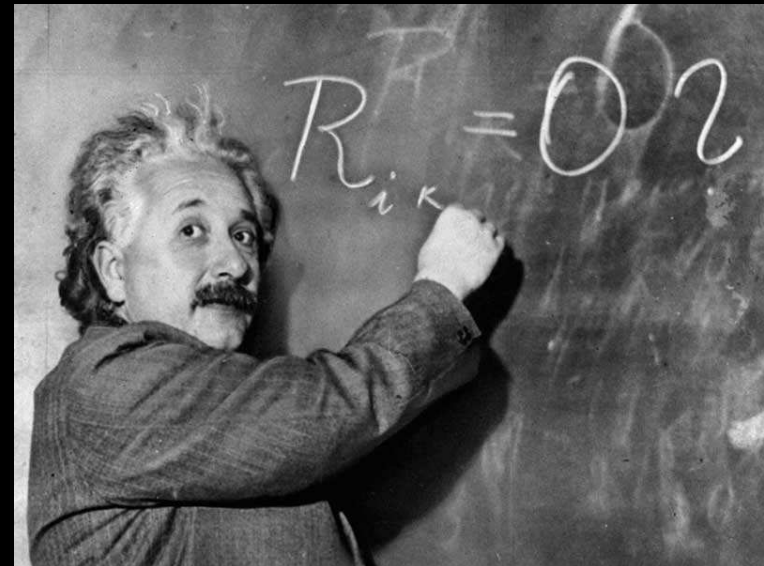
## ➤ *History (cont'd)*

### ➤ *Relativity:*

#### ➤ *Einstein (1879-1955):*

- *Special Theory of Relativity (1905)*
- *General Theory of Relativity (1916)*
- *Mass = function of Speed*

➤ *Despite the limitation due to Relativity Theory Newtonian Mechanics remains the basis of Engineering Sciences*



# Fundamental Concepts & Principles (Cont'd)

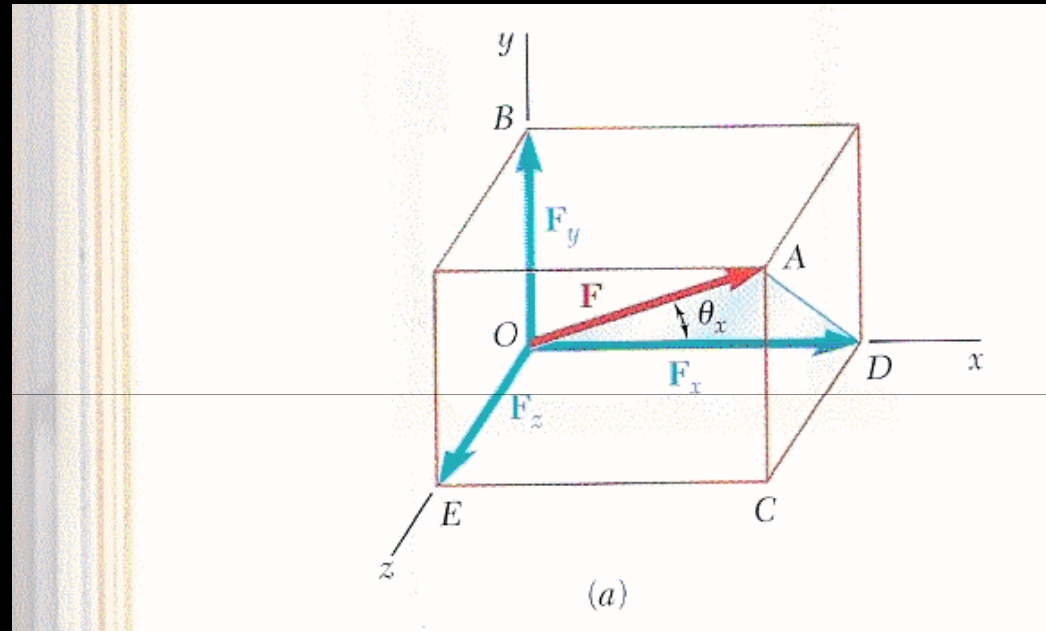
## ➤ *Basic Concepts:*

1. *Space*
2. *Time*
3. *Mass*
4. *Force*

*Those concepts are of a Principles nature.*

*In Newtonian Mechanics: Space, Time,  
Mass → Absolute Concept*

*Force → Dependant Concept*



# Fundamental Concepts & Principles (Cont'd)

➤ *Particles*

➤ *Rigid Bodies*

➤ *6 Fundamental principles*

1. *Parallelogram for addition of forces*

2. *Transmissibility (can be demonstrated)*

3. *1<sup>st</sup> Newton's Law: if  $\mathbf{F} = \mathbf{0}$  ... (derived from 4)*

4. *2<sup>nd</sup> Newton's Law:  $\mathbf{F} = m\mathbf{a}$*

5. *3<sup>d</sup> Newton's Law: Action  $\leftrightarrow$  Reaction*

6. *Law of Gravitation:*

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

$$g = 9.81 \text{ m/s}^2 \text{ or } 32.2 \text{ ft/s}^2$$

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# Unit Systems (SI, British Std etc)

## 1. *Basic Units*

➤ *Length, Mass, Time (SI) or Length, Force, Time (Engineering or technical)*

## 2. *Derived Units*

## 3. *Unit Prefixes*

| Factor    | Prefix | Symbol | Factor     | Prefix | Symbol |
|-----------|--------|--------|------------|--------|--------|
| $10^{12}$ | tera   | T      | $10^{-3}$  | milli  | m      |
| $10^9$    | giga   | G      | $10^{-6}$  | micro  | $\mu$  |
| $10^6$    | mega   | M      | $10^{-9}$  | nano   | n      |
| $10^3$    | kilo   | k      | $10^{-12}$ | pico   | p      |

# Unit Systems (SI, British Std etc)

|               | <i>SI</i>            | <i>Cgs</i>            | <i>Engineering Metric</i> | <i>British Std</i>    | <i>Engineering British</i> |
|---------------|----------------------|-----------------------|---------------------------|-----------------------|----------------------------|
| <i>L</i>      | <i>M</i>             | <i>Cm</i>             | <i>M</i>                  | <i>Ft</i>             | <i>Ft</i>                  |
| <i>M</i>      | <i>kg</i>            | <i>g</i>              | <i>masseau</i>            | <i>Slugs</i>          | <i>Lbm</i>                 |
| <i>T</i>      | <i>s</i>             | <i>s</i>              | <i>s</i>                  | <i>s</i>              | <i>S</i>                   |
| <i>F</i>      | <i>N</i>             | <i>Dyne</i>           | <i>kgf</i>                | <i>Lb</i>             | <i>Lb</i>                  |
| <i>P</i>      | <i>Pa</i>            | <i>Bar</i>            | <i>Kgf/mm<sup>2</sup></i> | <i>psf</i>            | <i>Psi</i>                 |
| <i>W or E</i> | <i>Joule</i>         | <i>erg</i>            | <i>Kgf m</i>              | <i>Lb ft</i>          | <i>Lb ft</i>               |
| <i>Heat</i>   | <i>Joule</i>         | <i>erg</i>            | <i>Calorie</i>            | <i>Lb ft</i>          | <i>BTU</i>                 |
| <i>Power</i>  | <i>Watt</i>          |                       | <i>CV</i>                 | <i>Lb ft/s</i>        | <i>HP</i>                  |
| <i>Volume</i> | <i>m<sup>3</sup></i> | <i>cm<sup>3</sup></i> | <i>Litre</i>              | <i>ft<sup>3</sup></i> | <i>Gallon</i>              |

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# Conversion of Units systems

## 1. *Length*

$$1 \text{ ft} = 0.3048 \text{ m} \Rightarrow 1 \text{ mi} = 1609 \text{ m} \Rightarrow 1 \text{ NM} = 1.852 \text{ m}$$

$$1 \text{ in} = 1/12 \text{ ft} = 0.0254 \text{ m} = 25.4 \text{ mm}$$

## 2. *Force*

$$\mathcal{W} = \mathcal{M}g \Rightarrow 1 \text{ lb} = 0.4536 \text{ kg} \times 9.807 \text{ m/s}^2 = 4.448 \text{ N}$$

## 3. *Mass*

$$1 \text{ slug} = \frac{1 \text{ lb}}{1 \text{ ft/s}^2} = \frac{4.448 \text{ N}}{0.3045 \text{ m/s}^2} = 14.59 \text{ N s}^2 / \text{m} = 14.59 \text{ kg}$$

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# Method Of Problem Solution

## *1. Statement of a problem*

- 1. Clear & precise*
- 2. Contain the given data*
- 3. Indicate what information is required*

## *2. Separate sketch(es)*

- 1. Free body diagram per bodies*
- 2. Including all quantities involved*
- 3. Indicating clearly all the forces*

## *3. Usage of fundamental principles*

- 1. To write equations*
- 2. Each equations clearly related to the free body diagram*

# Method Of Problem Solution (Cont'd)

## 4. *Solutions of the equation*

4. *Strict application of rules of Algebra*
5. *Record every step*

## 5. *Careful check*

1. *Reasoning mistake detected by checking units*
2. *Computation checked by usage of an equation not yet used*

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# Numerical Accuracy

- *It is useless to compute with extreme accuracy*
- *§ 1.2 optimistic i.e.*
  - Very often the accuracy of the forces is not better than 2 %.*
- *Calculation accuracy should be of the order of magnitude the accuracy of the data or the accuracy of the computation method whichever is less.*