CHAPTER ONE

General Principles

Mechanics: تتعلق مهندسة الميكانيك/ الهندسة المدنية وتكنولوجيا

Static: تتعلق بالقوى المستمرة في المكان/ القوىtube

Basic Quantities

<table>
<thead>
<tr>
<th>Length</th>
<th>Time</th>
<th>Mass</th>
<th>Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cm</td>
<td>1 s</td>
<td>1 kg</td>
<td>1 N</td>
</tr>
</tbody>
</table>

- Idealization: تتعلق مهندسة النسبية في الفيزياء
- Particle: جسم بسيط
- Rigid Body: جسم صلب
- Concentrated Force: قوة مركزية
Newton's 3 Laws of Motion

First law: The object will remain at rest or in uniform motion in a straight line unless acted upon by an external force.

Second law: The net force acting on an object is directly proportional to its mass and acceleration. \[ F = ma \]

Third law: For every action, there is an equal and opposite reaction. \[ F_{A on B} = F_{B on A} \]
\[ F = G \frac{m_1 m_2}{r^2} \]

- Newton's Law of Gravitational Attraction

- Weight:
  \[ W = G \frac{m G}{r^2} \]

- Given:
  \[ G = 6.67 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2} \]
  \[ m = 5.48 \text{ kg} \]
  \[ r = 0.016 \text{ m} \]

- Calculated:
  \[ F = 6.63 \times 10^{-10} \text{ N} \]
  \[ W = 1.38 \times 10^{-11} \text{ N} \]
Units of Measurement

- Length (m)
- Time (s)
- Mass (kg)
- Force (N)

**SI units**

**US Customary (FPS)**

- Length (ft)
- Time (s)
- Force (lb)
- Mass (slug)

1 N = The force required to give (1 kg) of mass an acceleration (1 m/s²)

\[ N = \text{kg} \cdot \text{m/s}^2 \]  
(from F = m.a)

\[ g = 9.81 \frac{\text{m}}{\text{s}^2} \]

A body with a mass (1 kg) has a weight \( W = 9.81 \text{ N} \)

Common Conversion Factor

\[ 1 \text{ ft} = 0.3048 \text{ m} \]

\[ 1 \text{ lb} = 4.4482 \text{ N} \]

\[ 1 \text{ slug} = 14.5938 \text{ kg} \]

**Ex:** Convert a torque value of 47 in. lb into SI units.

\[
\text{Sol.} \quad 47 \text{ in. lb} = 47 \times \text{lb} \times \frac{1\text{ ft}}{12\text{ in.}} \times \frac{0.3048 \text{ m}}{1\text{ ft}} \times \frac{4.4482 \text{ N}}{1\text{ lb}} = 5.31 \text{ m.N}
\]
SI Units

- No plurals (Ex. m = 5 kg not kgs)

- (Ex. meter-second = m.s)

- (Ex. m, kg, s and the exception are: N, Pa, M, G)

- Exponential power apply (Ex. cm² = cm . cm)

- Prefixes

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giga</td>
<td>G</td>
<td>10⁹</td>
</tr>
<tr>
<td>Mega</td>
<td>M</td>
<td>10⁶</td>
</tr>
<tr>
<td>Kilo</td>
<td>K</td>
<td>10⁴</td>
</tr>
<tr>
<td>Milli</td>
<td>m</td>
<td>10⁻³</td>
</tr>
<tr>
<td>Micro</td>
<td>μ</td>
<td>10⁻⁶</td>
</tr>
<tr>
<td>Nano</td>
<td>n</td>
<td>10⁻⁹</td>
</tr>
</tbody>
</table>

- Ex 4,000,000 N = 4,000 KN = 4 MN

- 0.005 m = 5 mm

- (kg / m³) Prefix

- Ex. do not write N / mm but rather N / m

- 1 m / kg = 1 / kg

- Prefixes

- Ex. (50 KN)(60 nm) = (50×10⁵ N)(60×10⁻⁹ m)

- = 3,000×10⁶ N.m

- = 3×10⁻³ N.m

- Prefix / base units
Calculations for Analysis

**General Procedure for Analysis**

1. **Identify Problem**
2. **Define Objectives**
3. **Collect Data**
4. **Model System**
5. **Simulate Solution**
6. **Analyze Results**
7. **Draw Conclusions**

**Case Study**

**Numerical Calculations**

- \( \frac{1}{2} + 1 = 1.5 \)
- \( 2 \times 3 = 6 \)
- \( 10 - 4 = 6 \)
- \( 5 - 3 = 2 \)
- \( 3 + 2 = 5 \)
- \( 7 - 2 = 5 \)
- \( 10 \times 0.5 = 5 \)
- \( 0.5 \times 10 = 5 \)
- \( \frac{1}{2} + \frac{1}{2} = 1 \)

**Example: Rounding Off Numbers**

- \( 3.5587 \approx 3.56 \)
- \( 0.3762 \approx 0.38 \)
- \( 0.5896 \approx 0.59 \)
- \( 2.846 \approx 2.85 \)
- \( 9.39 \approx 9.4 \)

**Dimensional Homogeneity**

- \( m = \frac{S}{g} \)

**Significant Figures**

- For small numbers, write: 0.00058 \( \approx 5 \times 10^{-4} \)
- For large numbers, write: 234100 \( \approx 2.341 \times 10^5 \)

**Distance vs. Speed vs. Time**

- \( d = \frac{1}{2}at^2 \)
- \( v = at \)
- \( t = \frac{d}{v} \)

**Conclusion**

- The calculations are completed successfully.

**Final Thoughts**

- The problem was solved effectively.

- Further analysis is recommended for more accurate results.
Ex 1 Convert 2 km/h to m/s (ans. = 0.556 m/s)

Ex 2 Evaluate:
(a) (50 mN)(6 GN) (ans. = 300 kN²)
(b) (400 mm)(0.6 MN)² (ans. = 144 Gm. N²)
(c) 45 MN³/900 Gg (ans. = 50 KN³/kg)

Ex 3 Represent each of the following combinations of units in the correct SI form using an appropriate prefix:
(a) kN/ms
(b) Mg/kN
(c) kN/(kg.ms)

Ex 4 Determine the mass in kilograms of an object that has a weight of:
(a) 50 mN
(b) 250 kN
(c) 800 MN

Ex 5 Evaluate: (204 mm)(0.00457 kg)/(34.6 N). Express the answer in SI units using an appropriate prefix.

Ex 6 Two particles have a mass of (8 kg) and (12 kg) respectively. If they are (800 mm) apart, determine the force of gravity acting between them. Compare this result with the weight of each particle.