Statics and Basic Mechanics

Gabriel Hugh Elkaim
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Forces (in general)

- Useful concept to describe the way in which bodies interact.

Force - vector quantity (directed).

Statics (Civil Engineering)
- Balanced Forces
  \[ \sum F = \emptyset \]
  \[ \rightarrow - ma \]

Dynamics
- Accelerated Force
  \[ \sum F = ma = \frac{d^2x}{dt^2} \]
  \[ \rightarrow - ma \]
External Forces: Normal
External Forces: Moments

\[ \sum \vec{F} = \vec{0} \]

\[ \sum M = \phi \]

\[ M = I \times \vec{F} \]
Forces: Compression

Aspect Ratio matters

Buckling

Trusses
Forces: Tension

Aspect ratio does not matter.

Mark's Properties of Materials:

\[ M = \int \rho A dl \]

\[ \sigma = \frac{F}{A} = \frac{\rho AL}{A} \]

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Carrying Forces (loads)

**True Forces**

1. Flexible cable, belt, chain, or rope
   - Weight of cable negligible
   - Weight of cable not negligible

**Idealized Forces**

- Force exerted by a flexible cable is always a tension away from the body in the direction of the cable.

\[ T \cos \theta \]
Carrying Forces (loads)

2. Smooth surfaces

Contact force is compressive and is normal to the surface.
Carrying Forces (loads)

3. Rough surfaces

\[ F = \mu N \]

Rough surfaces are capable of supporting a tangential component \( F \) (frictional force) as well as a normal component \( N \) of the resultant contact force \( R \).

Coefficient of friction - Static friction \( \mu_s \)
Dynamic friction \( \mu_d \)

- Ice \( \sim 0.1 \)
- 0.7
Carrying Forces (loads)

4. Roller support

Roller, rocker, or ball support transmits a compressive force normal to the supporting surface.
Carrying Forces (loads)

5. Freely sliding guide

Collar or slider free to move along smooth guides; can support force normal to guide only.

pin in slot
sleeve on shaft
Carrying Forces (loads)

6. Pin connection

A freely hinged pin connection is capable of supporting a force in any direction in the plane normal to the axis; usually shown as two components $R_x$ and $R_y$. A pin not free to turn may also support a couple $M$. 
Carrying Forces (loads)

Cantilever

7. Built-in or fixed support

A built-in or fixed support is capable of supporting an axial force $F$, a transverse force $V$ (shear force), and a couple $M$ (bending moment) to prevent rotation.
The Basics of Statics

\[ \sum F = \Phi \]
\[ \sum M = \Phi \]

Linear Momentum
\[ m \vec{v} \text{ or } m \vec{a} \]

Free Body Diagram

\[ \sum \vec{F} = m \ddot{\vec{x}} \]
\[ \sum \vec{M} = I \ddot{\theta} \]

Angular Momentum
\[ I \vec{\omega} \text{ or } J \ddot{\theta} \]

Gravitational Force
\[ F = mg \]
An Example: A Pulley

Fig. P6-46

\[ P = \frac{mg}{4} \]
Examining a Robot

1. How is the weight of the thing supported?
2. How does it change if it is under motion?
3. Other interesting aspects of the device?
4. Draw a free-body diagram of part 1 (and if you feel ambitious, part 2).
Questions?
Questions
Mechanical CAD

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Mechanical CAD

- Communication Mechanical Ideas to Someone else

Computer Aided Design
What is CAD?

Software World — Auto coders

Dave - Infineon
Simulink/MATLAB
What is CAE?

Computer Aided Engineering

Mechanical - Finite Element Analysis (FEA)
   - Cosmos/MD, ANSYS

Electrical - SPICE Circuit Simulation
   - Auto-热播

Software - Auto Coders (CAE)
   - Optimizers
   - Simulink/Modelica
   - Matrices
What is CAM?

Computer Aided Manufacturing

Mechanical -

CNC machining
Lathe cutting

Additive Manufacturing -

SLS print
Vapor deposition
Extruders

RCM
60 ksi
Traditional 3-View Drawing

Top

Front

Side

Remember Dimensions
Questions?
Shape ways
$ 45/kb
(Laser)

Next Source

Fire Triangle

Fuel

Oxygen (Air)

Don't Panic