Statics and Basic Mechanics

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Forces (in general)

- Useful way to describe the ways in which bodies interact

- Vectors
  - magnitude
  - direction

- Two cases
  1) balance (statics)
     \[ \Sigma F = 0 \quad \Sigma m = 0 \]
  2) in motion
     \[ \Sigma F = ma = m\ddot{x} \]
External Forces: Normal
External Forces: Moments

\[ \sum F = ma \]

\[ \sum M = I \cdot \dot{\theta} \]

\[ \frac{d^2 \theta}{dt^2} \]
Forces: Tension

Aspect Ratio matters

Keep paper feeding
Forces: Compression

Tension

aspect ratio does not matter

Length + width
Forces: Bending
Robot Frame
Carrying Forces (loads)

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

True Force

Free Body Diagram (Cable)

Force exerted by a flexible cable is always a tension away from the body in the direction of the cable.
Carrying Forces (loads)

2. Smooth surfaces

No Friction

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

3. Rough surfaces

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

$$F = \mu N$$
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.
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 $M$. 

Pin free to turn

Pin not free to turn
Carrying Forces (loads)

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

\[ \sum F = m a = 0 \]

\[ \sum F = \phi \]

\[ \sum M = I \phi \]

\[ \sum M = \phi \]

\[ f - ma = 0 \]

\[ F = ma \]
An Example: A Pulley

Fig. P6-46

\[ p = \frac{mg}{2} \]

\[ 2p + T = mg \]

\[ 2p = T/2 \]

\[ 2p + 2p = mg \]

\[ p = \frac{mg}{4} \]
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?