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 ways

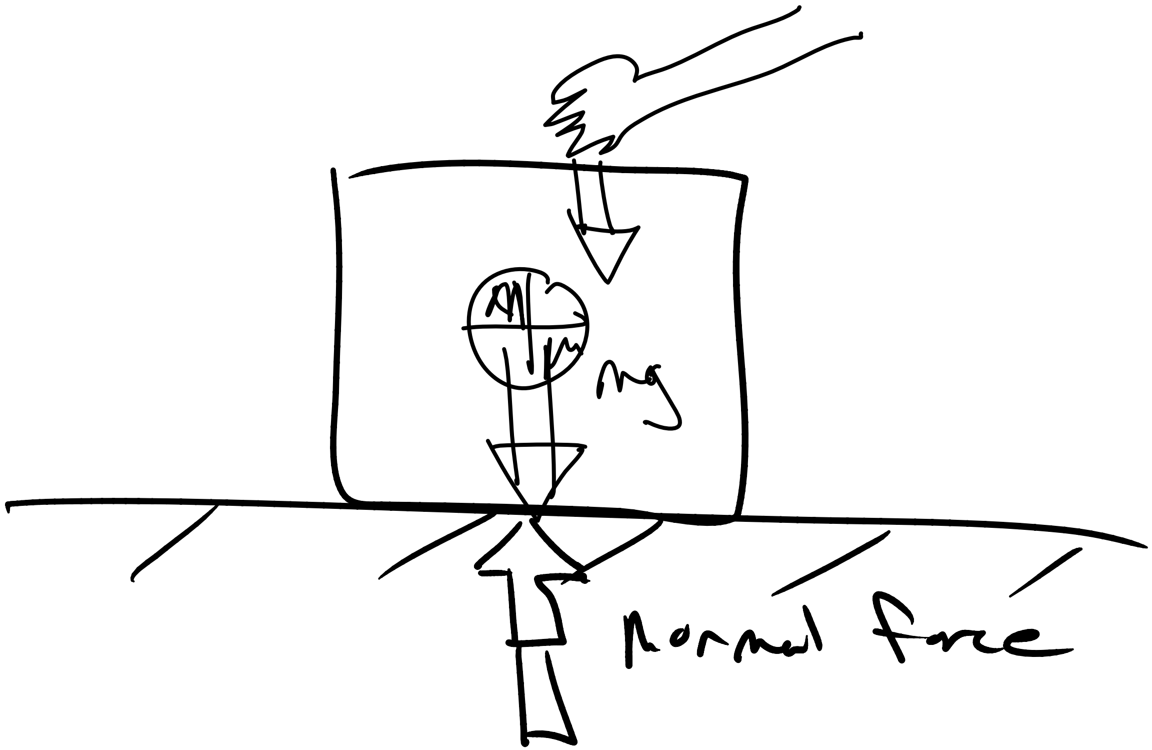
1) balance (statics)

$$\sum F = 0 \qquad \sum M = 0$$

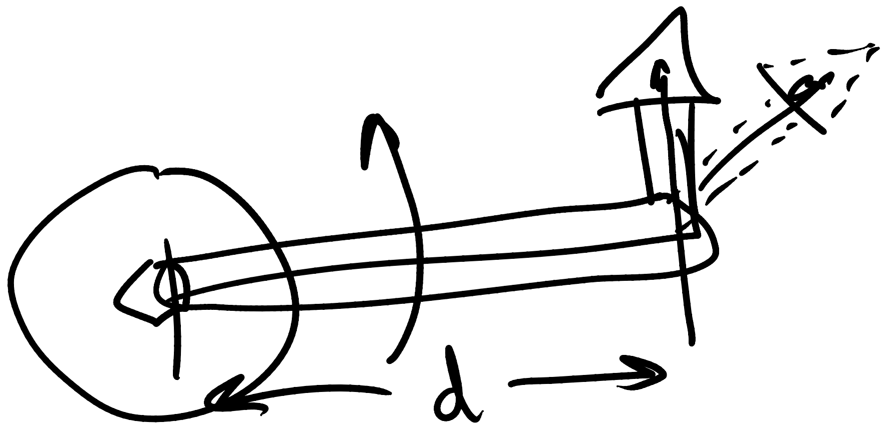
2) in motion

$$\sum F = ma = m\ddot{x}$$

External Forces: Normal



External Forces: Moments



$$m = F \times d$$

$$\sum F = ma$$

Forces

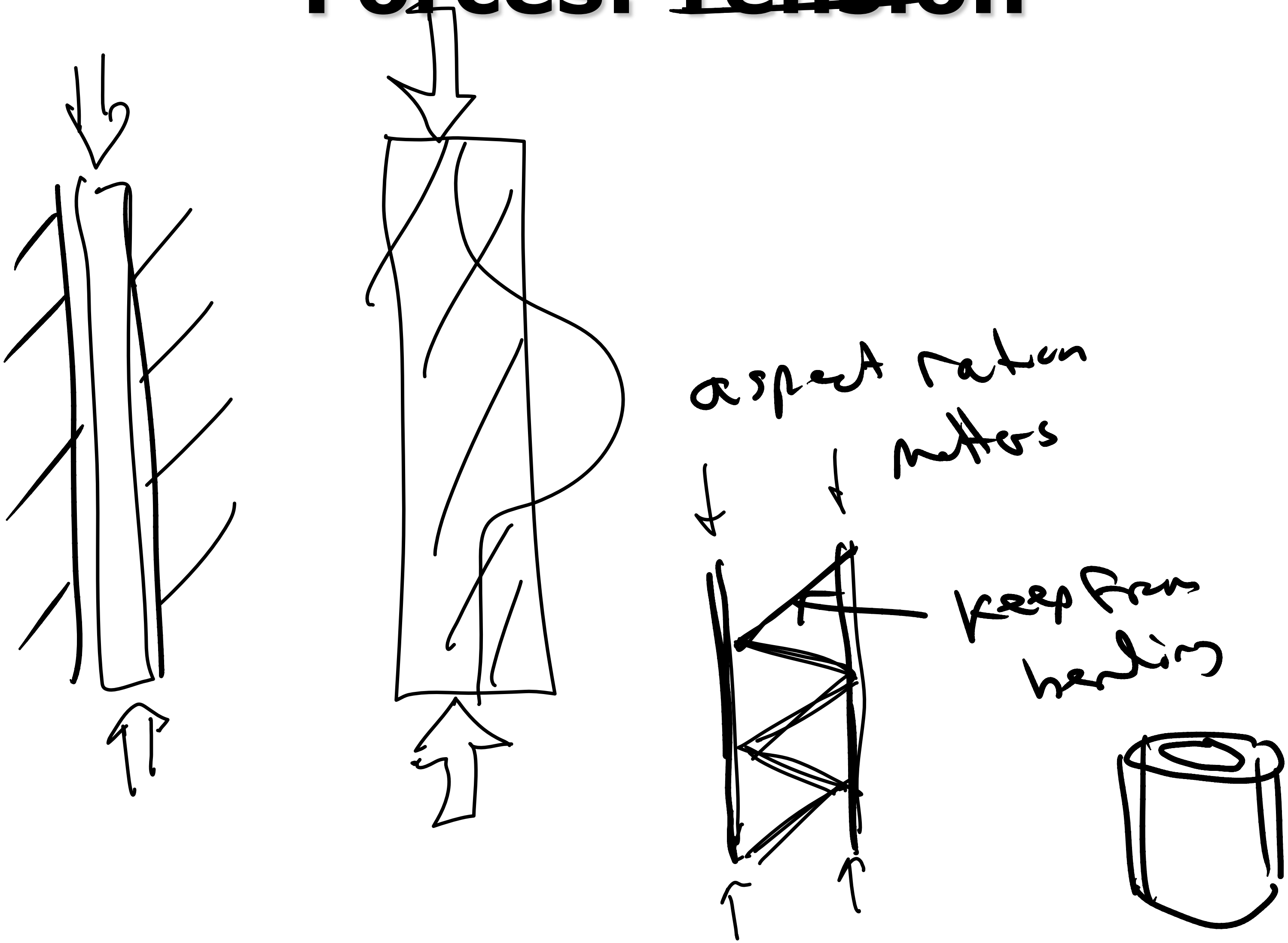
$$\sum M = I \cdot \ddot{\theta}$$

angular moment of inertia

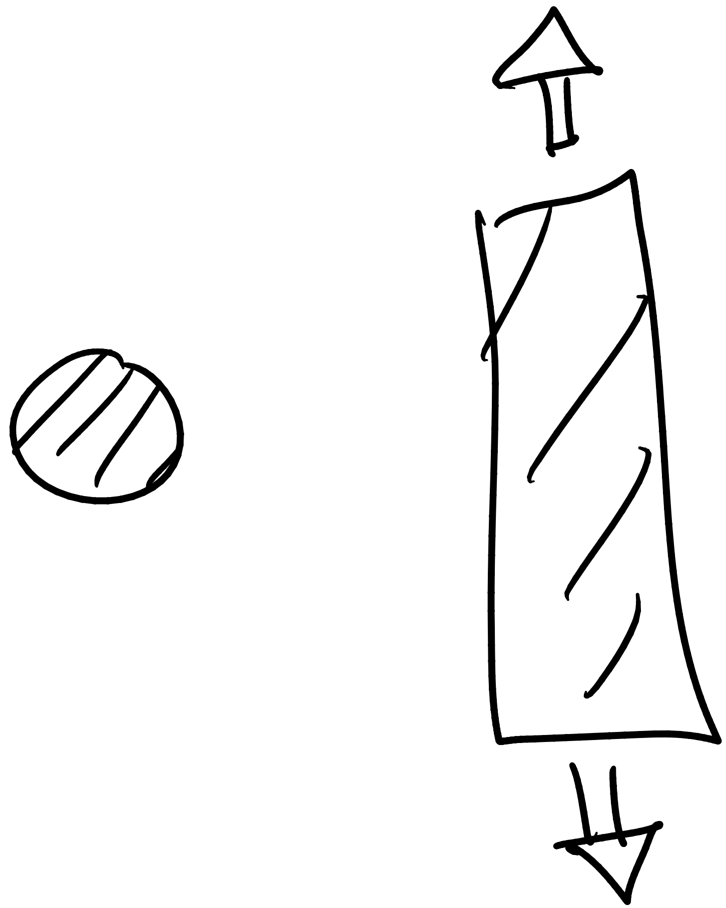
theta

$$\frac{d^2\theta}{dt^2}$$

Forces: ~~Tension~~ Compression



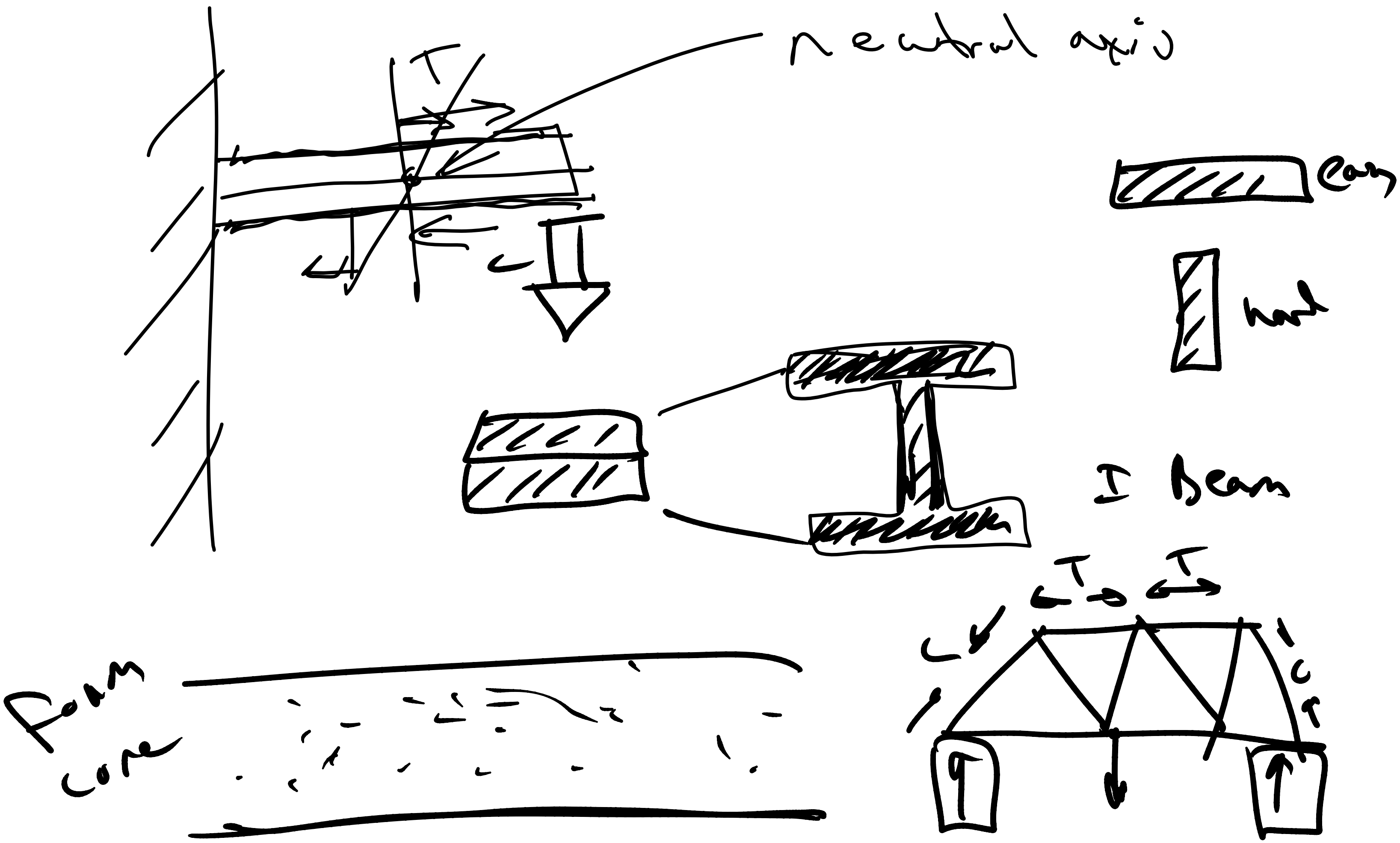
Forces: ~~Compression~~ Tension



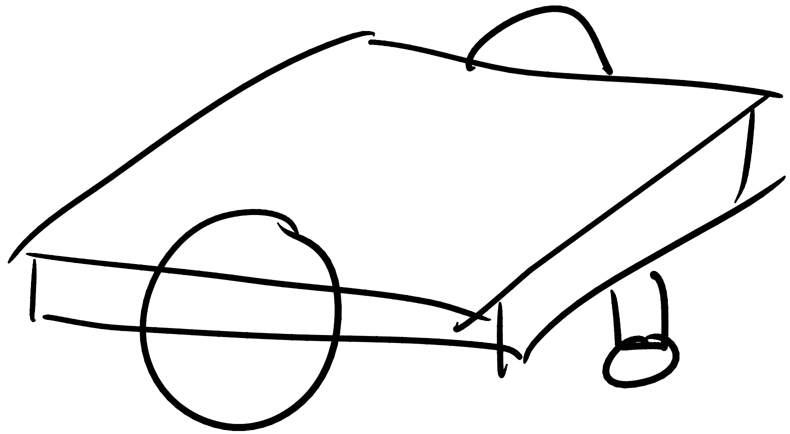
aspect ratio does not matter

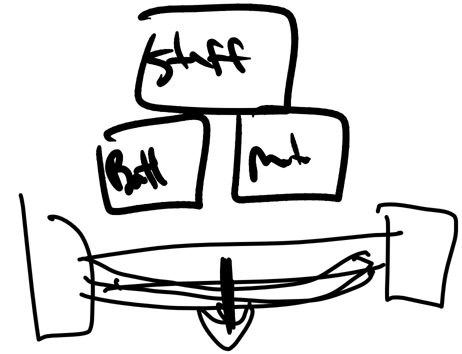
Length + width

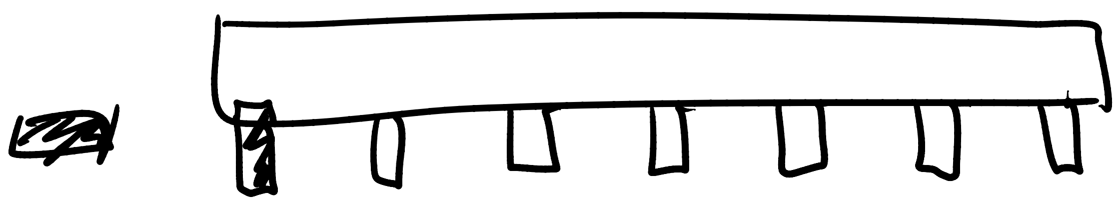
Forces: Bending

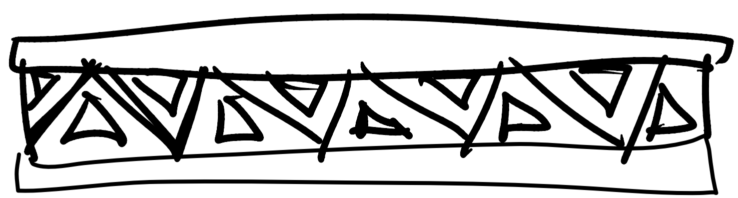


Robot Frame









Carrying Forces (loads)

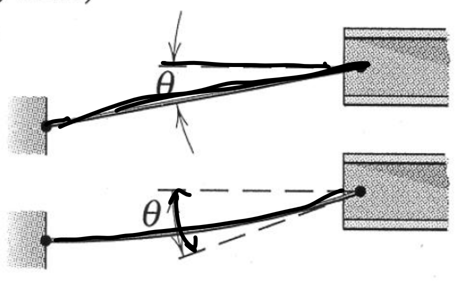
True Forces

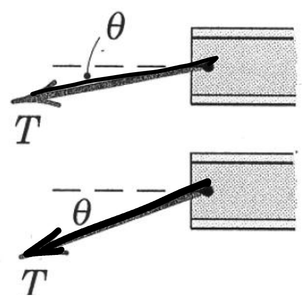
Free Body Diagram (idealized)

1. Flexible cable, belt, chain, or rope

Weight of cable negligible

Weight of cable not negligible



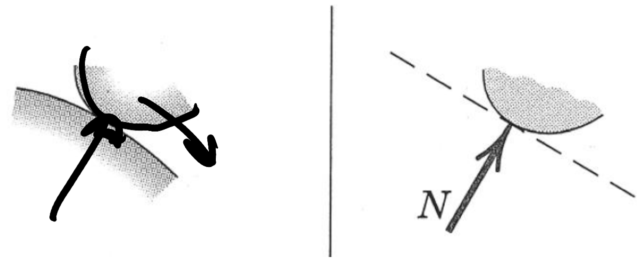


Force exerted by a flexible cable is always a tension away from the body in the direction of the cable.

Carrying Forces (loads)

No Friction

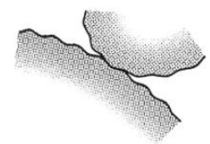
2. Smooth surfaces

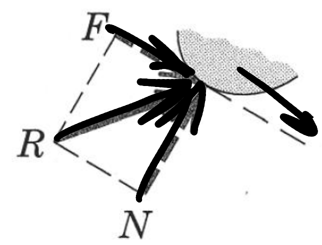


Contact force is compressive and is normal to the surface.

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.

Coefficient of friction

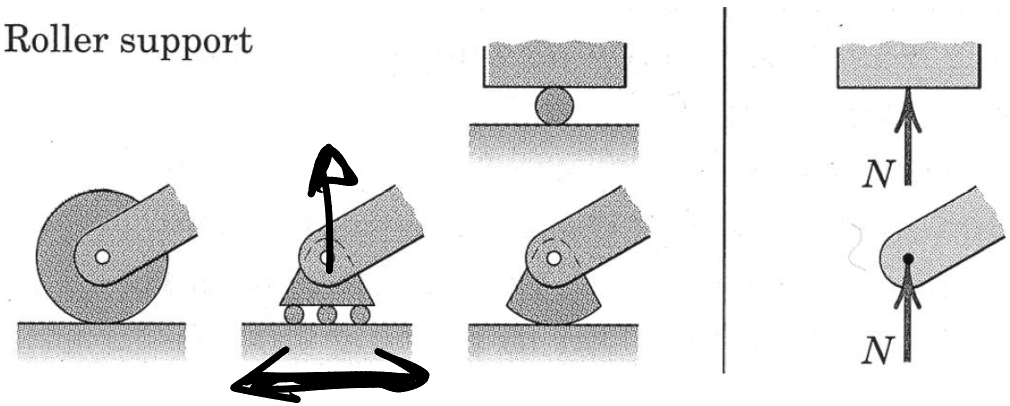
$$F = \mu N$$

dynamic or static

normal force

Carrying Forces (loads)

4. Roller support

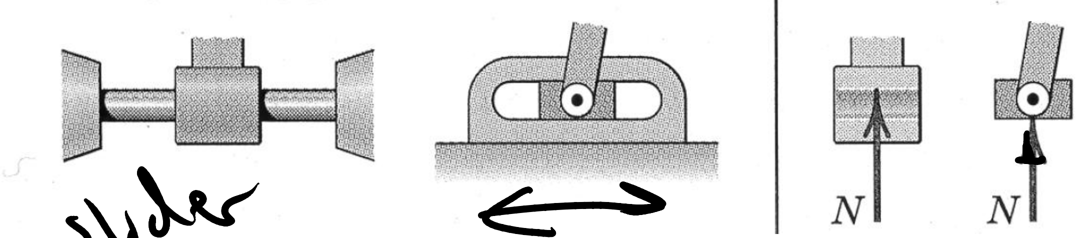


Roller, rocker, or ball support transmits a compressive force normal to the supporting surface.

Carrying Forces (loads)

pin in slot

5. Freely sliding guide



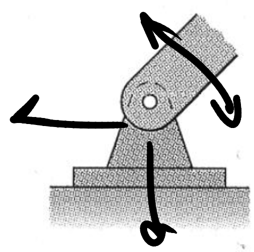
slider

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

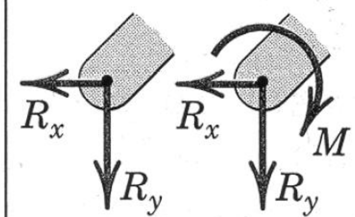
geneva gear

Carrying Forces (loads)

6. Pin connection



Pin free to turn | Pin not free to turn

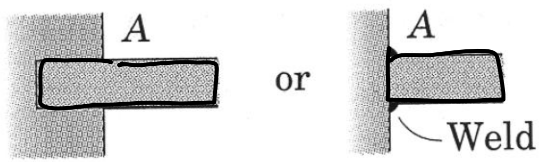


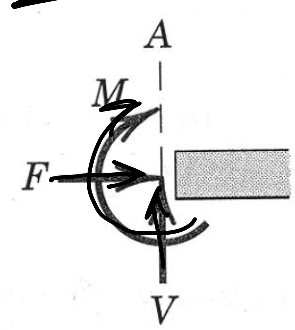
A freely hinged pin connection is capable of supporting a force in any direction in the plane normal to the axis; usually shown as two components R_x and R_y. A pin not free to turn may also support a couple M.

Carrying Forces (loads)

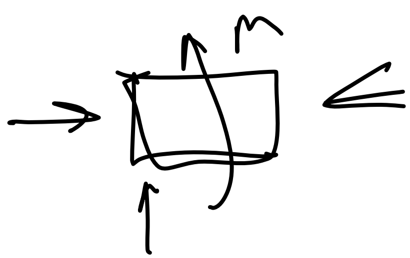
Cantilever

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

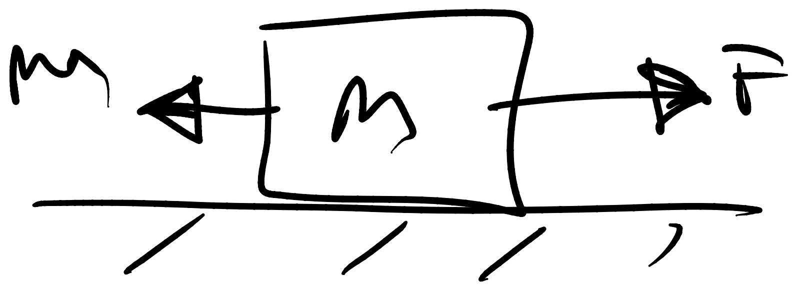
$$\sum F = m a \to 0$$

$$\sum M = I \ddot{\theta} \to 0$$

$$\sum F = 0$$

$$\sum M = 0$$

Not moving
Not rotating



$$F - ma = 0 \qquad F = ma$$

An Example: A Pulley

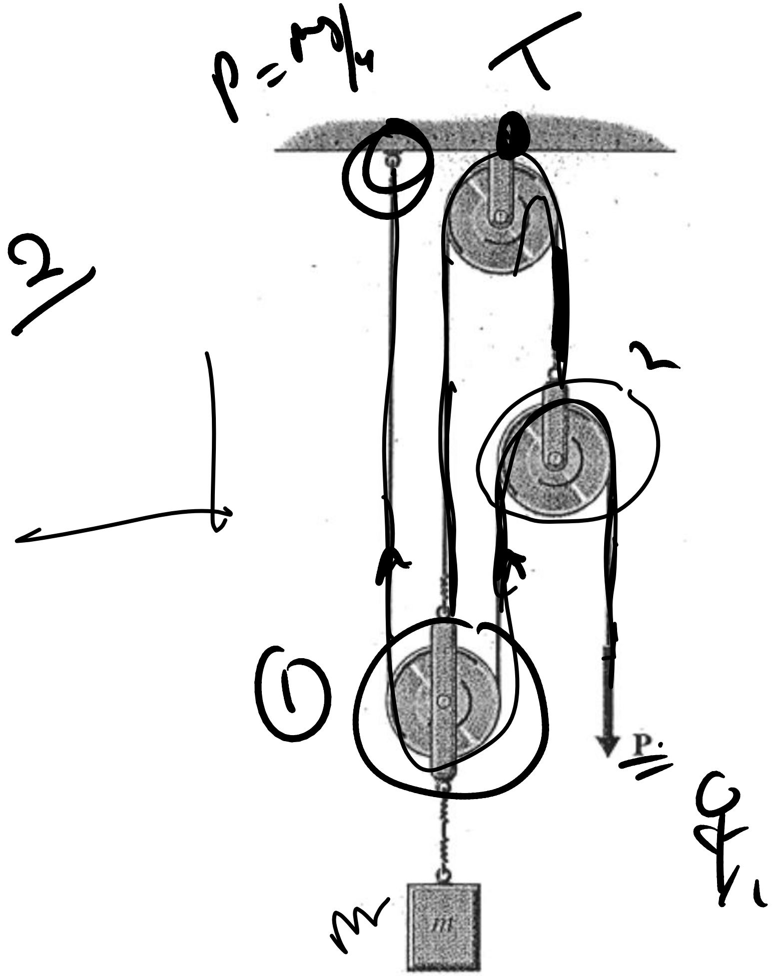
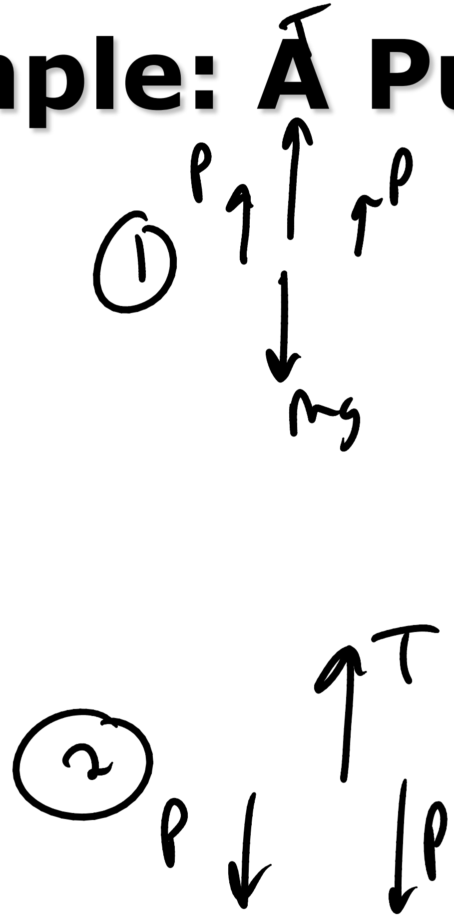


Fig. P6-46



$2P + T = mg$

$2P = T$

$2P + 2P = mg$

$$P = \frac{mg}{4}$$

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?