Lecture 22:
Static Equilibrium

- Conditions for static equilibrium
- Examples

Conditions for static equilibrium

No linear acceleration:

$$\sum \vec{F} = 0$$

No angular acceleration:

$$\sum \vec{\tau} = 0$$

Two-dimensional problems

All forces act in one plane, the xy-plane
→all torques perpendicular to this plane, in z-direction

$$\sum F_x = 0$$

$$\sum F_y = 0$$

$$\sum \tau_z = 0$$

Choice of reference point for torques

Object does not rotate → may choose *any* point about which to calculate torques.

Reference point along the line of action of a force: moment arm is zero →no torque

Convenient choice of reference point:

- point where several forces act
- point where unknown force acts

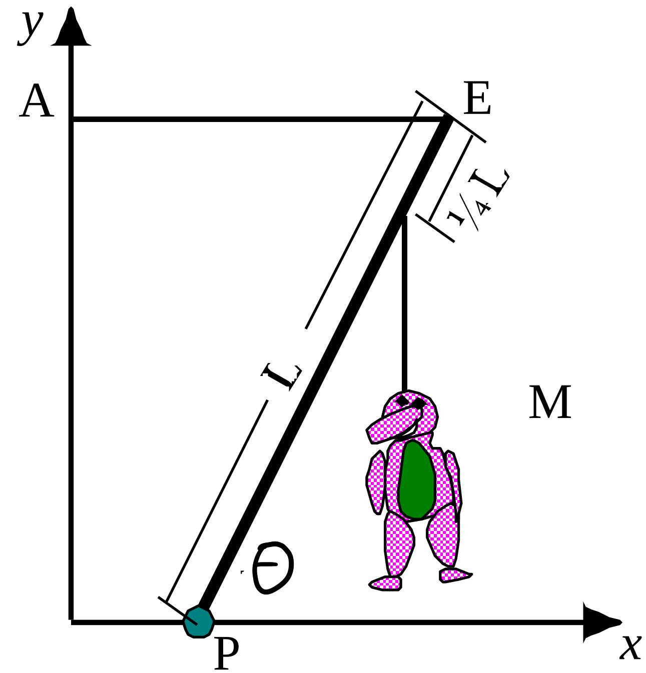
Easy Example:

Father and son on see-saw

Father (mass m_1) and son (mass m_2) are on a see-saw, which is a beam of mass M and length L that is pivoted in the middle. The son sits at one end. How far from the middle does the father have to sit for the see-saw to be in equilibrium?

Example

A massless beam of length *L* has its lower end pivoted at **P** on the floor, making an angle θ with the floor. A horizontal cable is attached from its upper end **E** to a point **A** on a nearby wall. A rope is attached at one-fourth of the way down from the beam's upper end, and hangs vertically downward. A disgustingly cheery purple dinosaur of mass *M* is attached motionless to the end of the rope.

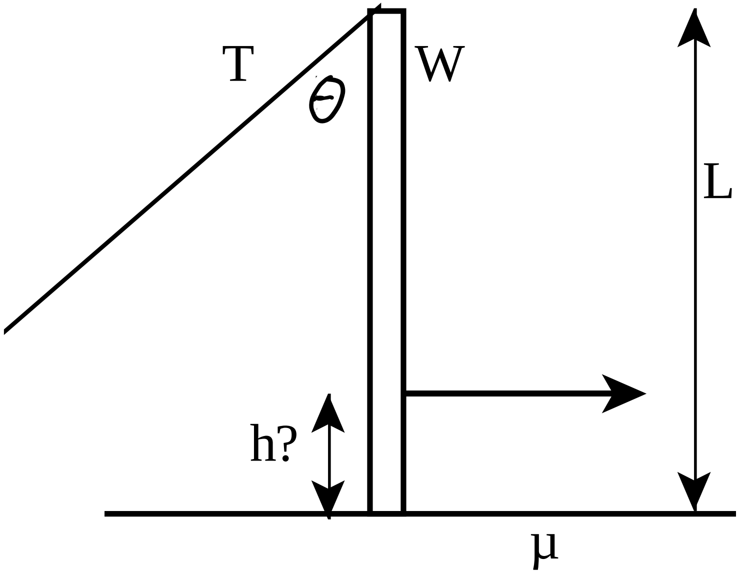


Derive an expression for the tension in the horizontal cable **AE.**

What are the x and y components of the force exerted by the pivot on the lower end of the beam?

Complex example

A uniform beam of length *L* and weight *W* is set upright on a rough floor which has a coefficient of static friction μ with the beam. A constant, horizontal pulling force is applied to the beam at some height above the ground. A rope which makes an angle θ with the beam is attached to the top end of the beam. The tension in the rope is *T*. The lower end of the beam is **just about to slide**.



Derive an expression for the height *h* above the ground at which the pulling force is applied, in terms of relevant system parameters.