Physics 101.

Lecture 18.

Wed. Feb. 12, 2003.

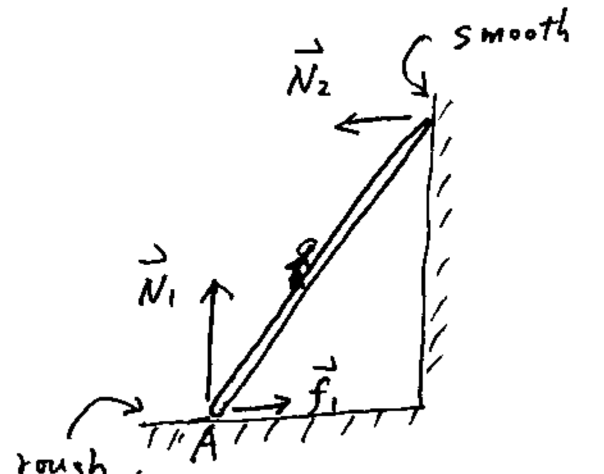
Topics Covered:

- Different supports / statics
- Angular momentum
- Rotational work.

Ref: 11-4, 5, 6, 7, 8.

- Last lecture.

  Climbing a ladder.



- statics:

$$\Sigma \vec{F}_i = 0$$

$$\Sigma \tau_i = 0.$$

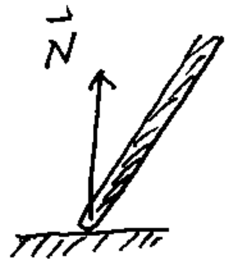
Choose an axis of rotation such that the Torque of unknown forces is zero.

Sign of a torque: + : C.C.W

− : CW

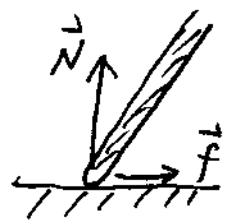
- Different kinds of supports:

1. { Rigid body. can slide No friction.



Normal force only. (Simplest)

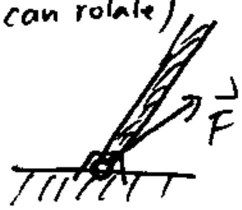
2. { Rigid body. can slide with friction.



Normal force and friction. (more complicated. but. $f \leq \mu N$)

3. { Rigid body can not slide

(can rotate)



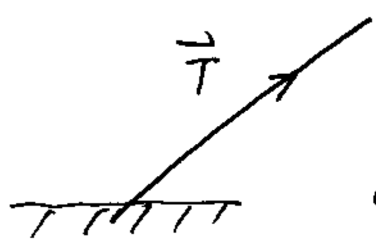
OR:

can not rotate.

$\vec{F}$ — with an unknown direction.

usually, [redacted] $\vec{F}$ is NOT along the beam.

4. { Cable. (flexible) fixed. }



Tension $\vec{T}$ is always along the cable.

e.g.: Next Monday.

- Angular Momentum
  - A quantity that describes rotational motion

(just like momentum is a quantity that describes linear motion. — also called linear momentum
$$p = mv.$$)

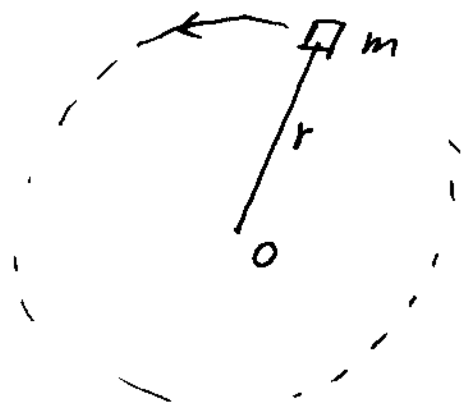
- Angular momentum of a rotating rigid body

$$L = I \cdot \omega$$

I — moment of inertia about O.

ω — angular velocity about O.

e.g. A particle at the end of a massless rod in a circular motion



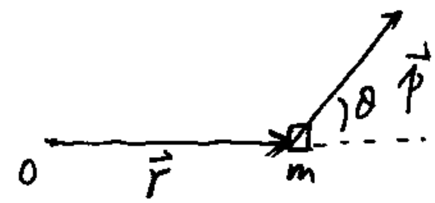
$I = mr^2$

$$\begin{aligned} L &= I\omega \\ &= mr^2 \cdot \omega \\ &= mr \cdot v \\ &= r \cdot mv \\ &= rp. \end{aligned}$$

$$L = r P_t .$$ (angular momentum about O)

- Angular momentum of a moving particle.
  (can be moving in a straight line!)

The angular momentum of m about O:



$$L = r \cdot p_t$$

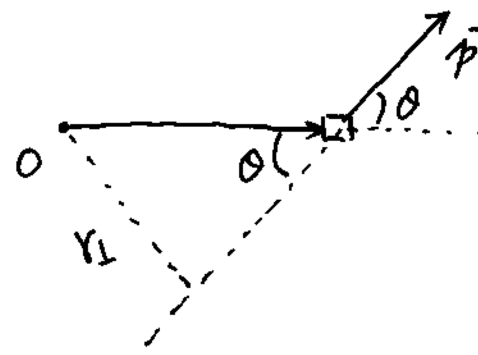
$$= r \cdot p \sin\theta$$

$$= p \cdot r \cdot \sin\theta$$

$$= p \cdot r_\perp .$$

θ — angle between $\vec{p}$ and $\vec{r}$.

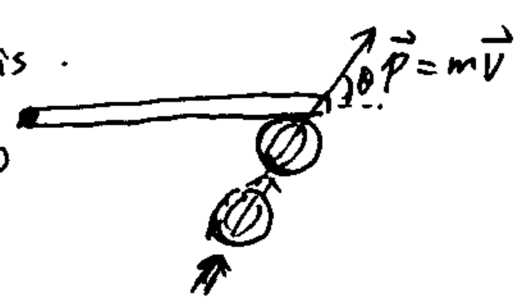
$r_\perp$ — moment arm.



- How can a particle in a linear motion have angular momentum?

  e.g.: Use a basketball to open a door.

The angular momentum of the ball about the axis of the door can be transfered to the door and causes the rotation of the door



$$L = r \cdot p_t = r_\perp p = r \cdot p \cdot \sin\theta$$

- Newton's 2nd law for Rotational motion

$$\tau = I \cdot \alpha = I \cdot \frac{\Delta \omega}{\Delta t} = \frac{\Delta L}{\Delta t}.$$

$$\therefore \quad \tau = \frac{\Delta L}{\Delta t}. \qquad \left(\text{just like } \vec{F} = \frac{\Delta \vec{p}}{\Delta t}\right)$$

- Conservation of angular momentum.

When $\tau = 0$. (No net torque)

$\Delta L = 0$, (No change in L)

i.e: $L = \text{const}$, $L_i = L_f$.

e.g: Figure skater.

$\tau = 0$.

$L_f = L_i$.

$I_f \cdot \omega_f = I_i \, \omega_i$

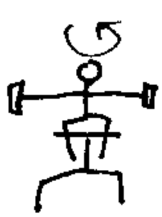
$\omega_f = \frac{I_i}{I_f} \omega_i$

If $I_f < I_i$, $\omega_f > \omega_i$ spin faster!

Large I_i.

Small I_f.

Demo:



I_i, ω_i.

I_f. ω_f.

$I_f < I_i$

$\omega_f > \omega_i$