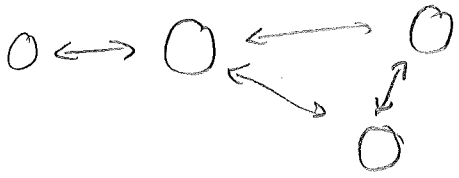
Props
- apple
- nail
- magnet
- book
- incline

[World is complicated.
Physics tries to simplify it to understand it.
Analyze it by breaking it into simple pieces
& then understand how pieces interact]



[What are the simple pieces?
If you're an elementary particle physicist,
the pieces are protons, electrons,
Accident reconstruction: 2 cars and a truck
Astrophysicist: stars & planets, or galaxies.

The hope is that the interactions between the
pieces are simple & that complication is
just a result of many simple things
Reductionism: very successful in physics]

- Isolate each object [mentally]
  and identify all forces acting on it

Force is a vector (magnitude and direction)
strength

[represent by an arrow]

length proportional to magnitude

[symbol]

$\vec{F}$

F = magnitude of $\vec{F}$

= mag $(\vec{F})$

= $|\vec{F}|$

Magnitude of a vector is always ≥ 0.

[Example: chalk on tray]

[Ask: what forces are acting?]

Types of forces

1) gravity: toward center of Earth $\downarrow \vec{F}_g$

$F_g = mg$ $\quad m$ = mass (kg)

$g = 9.8 \frac{m}{s^2}$

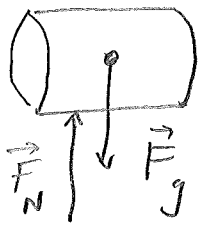
unit of force: Newton (N) $\quad 1\,N = \frac{kg \cdot m}{s^2}$

[grav. force on a small apple (3.6 oz) (~0.1 kg)]

2) normal: perpendicular to surface of contact and away from $\uparrow \vec{F}_N$

$F_N =$

- Draw a **free body diagram**: show all forces acting on object



- **Net force = sum of all forces acting on an object**

$$\vec{F}_{net} = \sum_{A=\text{forces}} \vec{F}_A$$

- **If object is at rest and remains so, net force must be zero.**

$$\vec{F}_g + \vec{F}_N = 0$$

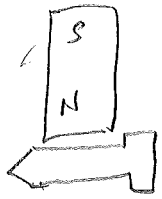
$$\vec{F}_N = -\vec{F}_g \qquad \text{[can do algebra on vectors]}$$

(opposite directions)

$$F_N = F_g$$

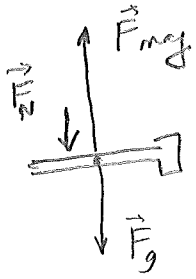
(equal magnitudes)

[next example: magnet holds nail]



[Draw FBD + compare w/ neighbor]

3) magnetic

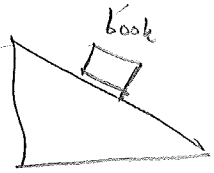


[Draw F_g, ask about other forces]

$$\vec{F}_{net} = \vec{F}_{mag} + \vec{F}_N + \vec{F}_g = 0$$

$$F_{mag} = F_N + F_g$$

[Q: what if increase strength magnet? A: F_N increases]

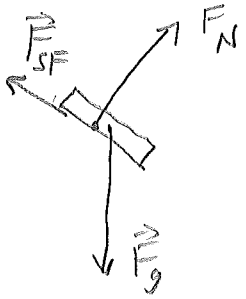


[Tell student to draw FBD]

4) static friction:
- parallel to surface of contact
- opposes tendency to move relative to surface

[which way would it tend to move if friction were absent?]

[draw F_g + F_N; as when else]

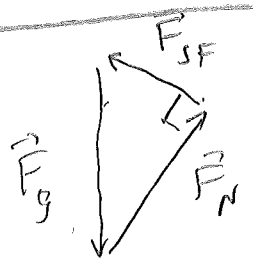


F_{SF} = it depends (adjustable up to a point)

$$\text{At rest} \Rightarrow \vec{F}_{SF} + \vec{F}_N + \vec{F}_g = 0$$

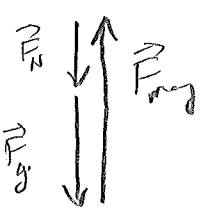
[How add vectors in different directions?]

vector addition: head-to-tail rule.



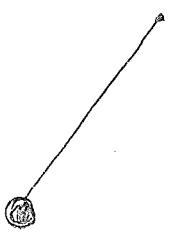
$$\Rightarrow F_g^2 = F_N^2 + F_{SF}^2$$

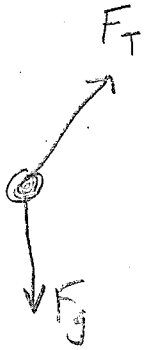
[magnitude:]



$$F_{mag} = F_N + F_g$$

Pendulum

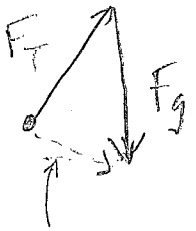




(add to list)

5. Tension: always along the string

Net force?

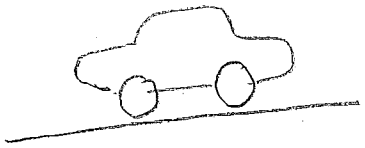


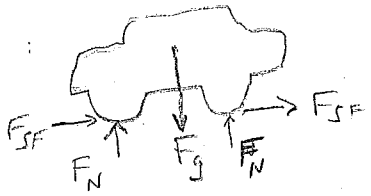
net force $\neq 0$ [pendulum not at rest!]

[optional]

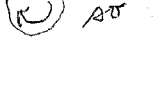
(optional: didn't do in S'10 or F'10)
did do in F'13

accelerating car
$\vec{a}$

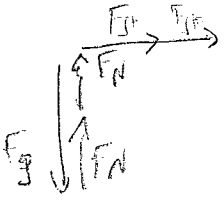




static friction because at point of contact, tire is stationary wrt road

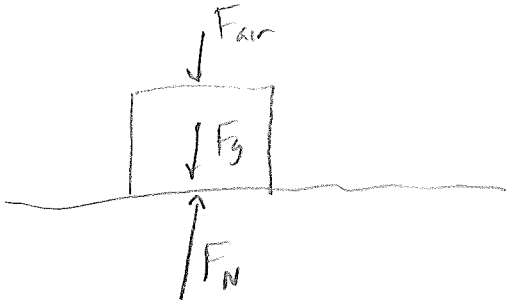
[w/o friction tending of motion,  so]

Net force



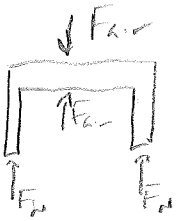
If asked:

What abt air pressure? Does that $\uparrow F_N$?



Yes but only to the extent that block is in contact w/ floor

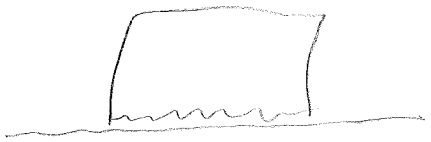
eg

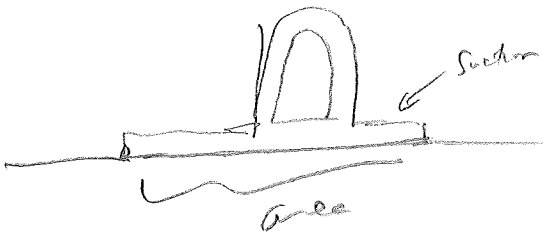


Here F_N is only increased by

$(14\ lbs/in^2) \cdot$ (area in contact)

If surface is rough air gets into space & no contact only occurs at small points





Now it will take

$F_{applied} = (14\ \frac{lbs}{in^2})$ (sealed area)

to lift the cup