Force
- A force is a push or pull on an object.
- Unit: Newton (N=kg m/s^2)

Weight
- The force due to gravitational attraction
- Towards center of earth
- **W** = m**g**

Normal Force
- Support force from a stable object
- Perpendicular to the surface

Spring Force (Hooke's law)
- Restoring force towards equilibrium
- **F**=k**x**

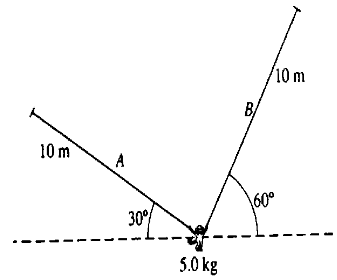
Friction
- The force that opposes a sliding motion
- Enables us to walk, drive a car, etc.
- Due to microscopic irregularities in even the smoothest of surfaces
- Static friction exists before sliding occurs (stationary)
- Kinetic friction exists after sliding occurs (moving)
- In general *Kinetic friction < Static friction*
- $f_s \le \mu_s N$
  - f_s : static frictional force (N)
  - μ_s: coefficient of static friction
  - N: normal force (N)
- Static friction increases as the force trying to push an object increases… up to a point!
- $f_k = \mu_k N$
  - f_k : kinetic frictional force (N)
  - μ_k: coefficient of kinetic friction
  - N: normal force (N)

Tension force
- From a rope, cable, chain, cord, string, etc.
- Only a pull (you can't push a rope)
- Acts in the direction of the rope
- ONE ROPE, ONE TENSION

Free body diagram
- A picture that shows all forces acting on an object
- Every force drawn as vector starting at center of mass
- Must have arrowheads
- Must be labeled: $mg(weight)$, $F_f(friction)$, $F_s(spring)$, $F_t(tension)$, $F_n(normal)$, $F_p(push)$, $F_b(buoyancy)$, F_a *(air resistance),* $F_e(electric)$, $F_m(magnetic)$

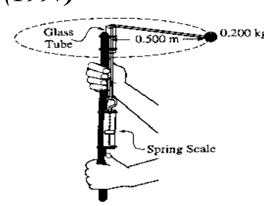
- Do NOT break forces into components on the FBD.
- Make a "working FBD" if you need to break the forces into x- and y- components.

Problem: FBD (1991)



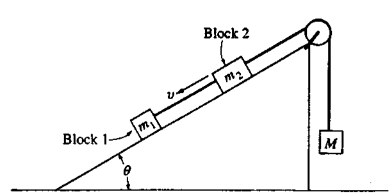
Draw a FBD for the monkey, which hangs from rest from two vines.

Problem: FBD (1997)

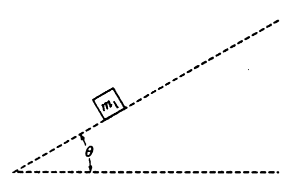


Draw vectors to represent the forces acting on the ball and identify the force that each vector represents. The cord is not horizontal.

Problem: FBD (2000)



Draw a FBD for m_1, moving with constant velocity down the ramp,



Newton's First Law

- The Law of Inertia
- Forces are balanced (UP=DOWN, RIGHT=LEFT)
- The net force is zero $\sum F = 0$
- The object is **at rest** or moving with **constant velocity**.
- Also called **static equilibrium** & **translational equilibrium**

Problem: Newton's 1st Law (1998)

7. Three forces act on an object. If the object is in translational equilibrium, which of the following must be true?

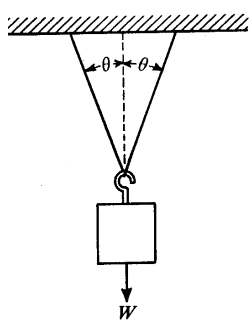
I. The vector sum of the three forces must equal zero.
II. The magnitudes of the three forces must be equal
III. All three forces must be parallel

(A) I only
(B) II only
(C) I and III only
(D) II and III only
(E) I, II, and III

Explain your reasoning

Problem: Newton's 1st Law (1988)

58. When an object of weight W is suspended from the center of a massless string as shown above, the tension at any point in the string is



(A) $2W\cos\theta$
(B) $\frac{W\cos\theta}{2}$
(C) $W\cos\theta$
(D) $\frac{W}{2\cos\theta}$
(E) $\frac{W}{\cos\theta}$

Show your work:

Newton's Second Law

- A body accelerates when acted upon by an unbalanced force.
- The acceleration is proportional to the net force and is in the direction which the net force acts.
- $\vec{F}_{net} = m\vec{a}$

  $\boldsymbol{F_{net}}$ is the net force measured in Newtons (N)
  m is mass (kg)
  $\boldsymbol{a}$ is acceleration (m/s^2)
- UP - DOWN=ma, RIGHT – LEFT=ma

Problem: Second Law (1993)

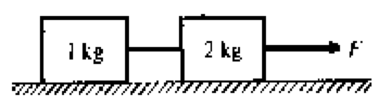
2. A ball falls straight down through the air under the influence of gravity. There is a retarding force F on the ball with magnitude given by F = bv, where v is the speed of the ball and b is a positive constant. The magnitude of the acceleration a of the ball at any time is equal to which of the following?

(A) $g-b$ (B) $g-\frac{bv}{m}$ (C) $g+\frac{bv}{m}$

(D) $\frac{g}{b}$ (E) $\frac{bv}{m}$

Show your work:

Problem: Second Law (1984)



11. When the frictionless system shown above is accelerated by an applied force of magnitude F, the tension in the string between the blocks is

(A) $2F$ (B) F (C) $\frac{2}{3}F$ (D) $\frac{1}{2}F$ (E) $\frac{1}{3}F$

Show your work:

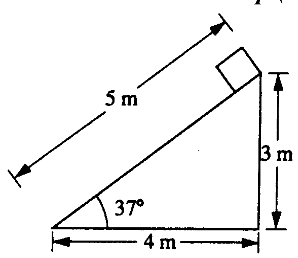
Newton's Third Law

- Forces come in equal and opposite pairs.
- Whenever two objects interact, the forces they exert on each other are equal in magnitude and opposite in direction.
- A weight force and normal force are NOT an example of Newton's 3rd law. Why not?

Ramp Problems

- Tilt the coordinate system so that the x-axis is parallel to the ramp and the y-axis is perpendicular to the ramp
- If the object is stationary or moving with constant speed, use Newton's 1st law: UP=DOWN, RIGHT=LEFT
- If the object is accelerating, use Newton's 2nd law for the horizontal direction: RIGHT-LEFT=ma, and use Newton's 1st law for the vertical direction: UP=DOWN

Problem: Normal Force Ramp (1993)



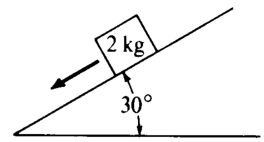
A plane 5 meters in length is inclined at an angle of 37 degrees, as shown above. A block of weight 20 newtons is placed at the top of the plane and allowed to slide down.

62. The magnitude of the normal force exerted on the block by the plane is most nearly

(A) l0 N
(B) 12N
(C) l6 N
(D) 20 N
(E) 33 N

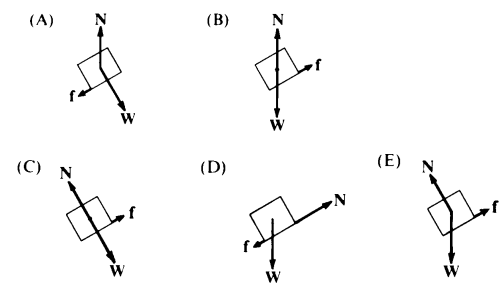
Show your work

Problems: Friction on Ramp (1984)



Questions 6-7:
A 2-kilogram block slides down a 30 degree incline as shown above with an acceleration of 2 meters per second squared.

6. Which of the following diagrams best represents the gravitational force W, the frictional force f, and the normal force N that act on the block?



7. The magnitude of the frictional force along the plane is most nearly
(A) 2.5 N
(B) 5 N
(C) 6 N
(D) 10 N
(E) 16 N

Show your work: