<u>Force</u>
A force is a *push* or *pull* on an object.
Forces cause an object to accelerate…
- To speed up
- To slow down
- To change direction

Unit: Newton (SI system)

<u>Newton's First Law</u>
The Law of Inertia.
A body in motion stays in motion at constant velocity and a body at rest stays at rest unless acted upon by an external force.
This law is commonly applied to the horizontal component of velocity, which is assumed not to change during the flight of a projectile.

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

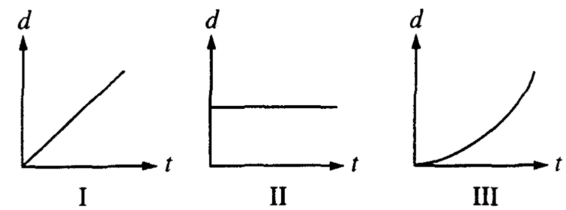
   (A) I only
   (B) II only
   (C) I and III only
   (D) II and III only
   (E) I, II, and III

Explain your reasoning

Problem: Newton's 1st Law (1998)

<u>Questions 43-44</u>

Three objects can only move along a straight, level path. The graphs below show the position d of each of the objects plotted as a function of time t.

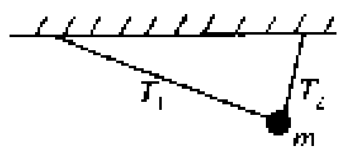


44. The sum of the forces on the object is zero in which of the cases?

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

Explain your reasoning

Problem: Newton's 1st Law (1984)

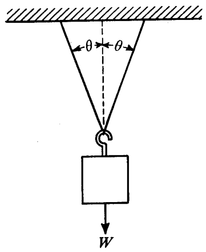


5. A hall of mass m is suspended from two strings of unequal length as shown above. The tensions T_1 and T_2 in the strings must satisfy which of the following relations?
   (A) $T_1 = T_2$
   (B) $T_1 > T_2$
   (C) $T_1 < T_2$
   (D) $T_1 + T_2 = mg$
   (E) $T_1 - T_2 = mg$

Show your work:

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:

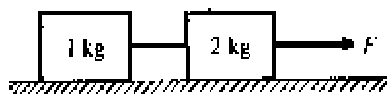
Newton's Second Law

A body accelerates when acted upon by a net external force.
The acceleration is proportional to the net force and is in the direction which the net force acts. This law is commonly applied to the vertical component of velocity.
Newton's Second Law
$\Sigma\mathbf{F} = m\mathbf{a}$
where $\Sigma\mathbf{F}$ is the net force measured in Newtons (N)
m is mass (kg)
$\mathbf{a}$ is acceleration (m/s^2)

General Procedure for Solving Second Law Problems

Step 1: Draw the problem
Step 2: Free Body Diagram
Step 3: Set up equations
$\Sigma\mathbf{F} = m\mathbf{a}$
$\Sigma F_x = ma_x$
$\Sigma F_y = ma_y$
Step 4: Substitute
Make a list of givens from the word problem.
Substitute in what you know.
Step 5: Solve

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:

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 t 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) $g - \frac{bv}{m}$

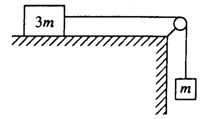
(C) $g + \frac{bv}{m}$

(D) $\frac{g}{b}$

(E) $\frac{bv}{m}$

Show your work:

Problem: Second Law (1993)



45. A block of mass 3m can move without friction on a horizontal table. This block is attached to another block of mass m by a cord that passes over a frictionless pulley, as shown above. If the masses of the cord and the pulley are negligible, what is the magnitude of the acceleration of the descending block?

(A) Zero
(B) g/4
(C) g/3
(D) 2g/3
(E) g

Show your work:

Newton's Third Law

For every action there exists an equal and opposite reaction.

If A exerts a force **F** on B, then B exerts a force of -**F** on A.

Weight

The force due to gravitation attraction.

W = m**g**

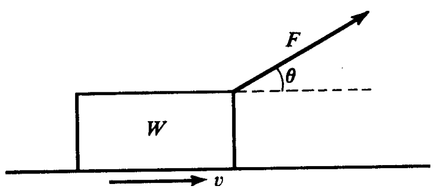
Normal Force

Force that prevents objects from penetrating each other

Reaction to other forces

Commonly a reaction to gravity

Problem: Normal Force Flat (1988)

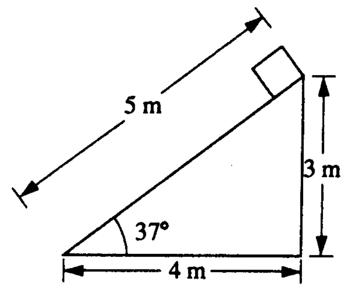


4. A block of weight *W* is pulled along a horizontal surface at constant speed *v* by a force *F*. which acts at an angle of θ with the horizontal, as shown above. The normal force exerted on the block by the surface has magnitude

(A) W - Fcos θ
(B) W - Fsin θ
(C) W
(D) W + Fsin θ
(E) W + Fcos θ

Show your work

Problem: Normal Force Ramp (1993)



A plane 5 meters in length is inclined at an angle of 37°, 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

Problem: Elevators and Normal Force (PAB)

2. A 50-kg middle school student stands on a scale in an elevator that is moving downward, but slowing with an acceleration of magnitude 2.0 m/s^2. What does the scale read (in N)?

a) 300
b) 400
c) 500
d) 600
e) 700

Show your work

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.
There are two types of friction
Static friction exists before sliding occurs
Kinetic friction exists after sliding occurs
In general *Kinetic friction* <= *Static friction*

Friction and the Normal Force

The frictional force which exists between two surfaces is directly proportional to the normal force.
That's why friction on a sloping surface is less than friction on a flat surface.

Calculating Static Friction

$f_s \leq \mu_s N$

f_s : static frictional force (N)
μ_s: coefficient of static friction
N: normal force (N)

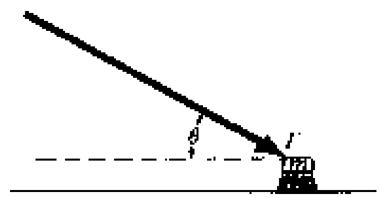
Static friction increases as the force trying to push an object increases… up to a point!

Calculating Kinetic Friction

$f_k = \mu_k N$

f_k : kinetic frictional force (N)
μ_k: coefficient of kinetic friction
N: normal force (N)

Problems: Friction on Flat Surface (1984)



61. A push broom of mass m is pushed across a rough horizontal floor by a force of magnitude T directed at angle θ as shown above. The coefficient of friction between the broom and the floor is It. The frictional force on the broom has magnitude

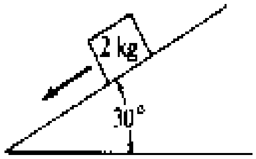
(A) $\mu(mg + T\sin\theta)$
(B) $\mu(mg + T\sin\theta)$
(C) $\mu(mg + T\cos\theta)$
(D) $\mu(mg - T\cos\theta)$
(E) μmg

Show your work

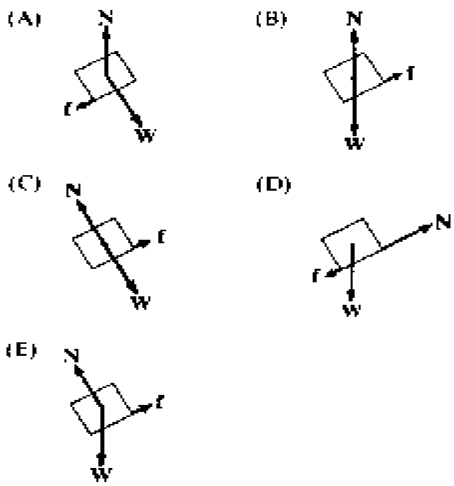
Problems: Friction on Ramp(1984)

<u>Questions 6-7</u>

A 2-kilogram block slides down a 30° 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: