Forces & Motion - I

Chapter 5

Introduction

- We’ve studied motion in one, two, and three dimensions… but what *causes* motion?
- This causality was first understood in the late 1600s by Sir Isaac Newton.
- Newton formulated three laws governing moving objects, which we call *Newton’s laws of motion*.
- Newton’s laws were deduced from huge amounts of *experimental evidence*.
- The laws are simple to state but intricate in their application.

Laws of Motion

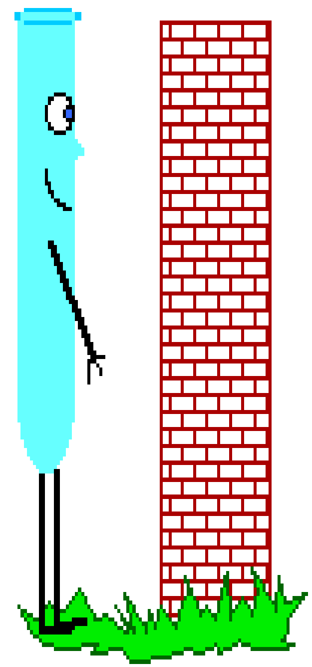
Force is associated with muscular activity and some change in the velocity of an object.

- Forces do not always cause motion.

For example

Computer on table, push the wall,

boy sitting on chair

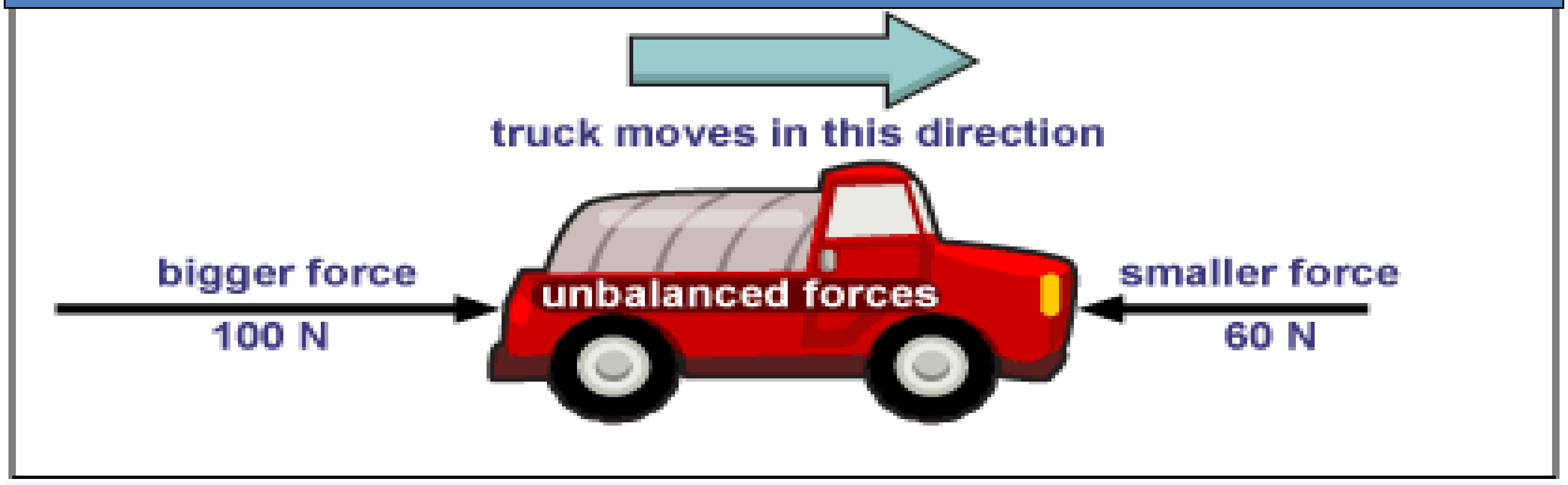


Balanced Force

Equal forces in opposite directions produce no motion

Unbalanced Forces

Unequal opposing forces produce an unbalanced force causing motion



Newton's Laws of Motion

1. An object in motion tends to stay in motion and an object at rest tends to stay at rest unless acted upon by an unbalanced force.
2. Force equals mass times acceleration (F = ma).
3. For every action there is an equal and opposite reaction.

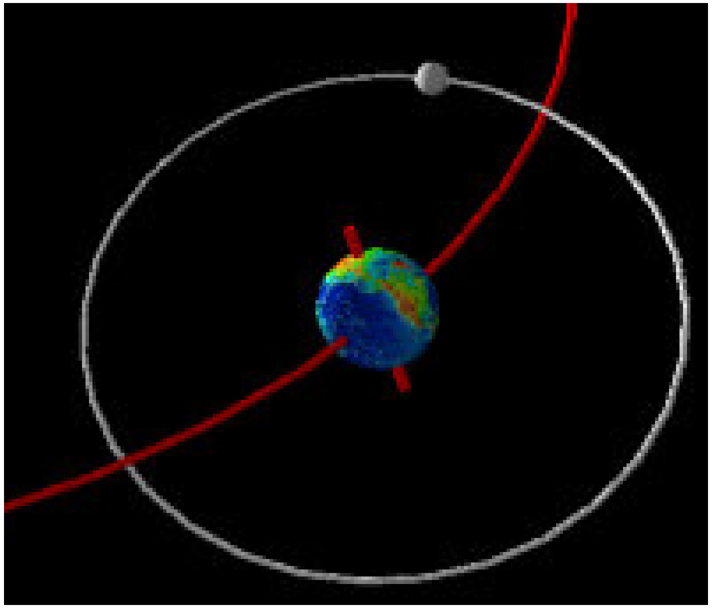
Classical or Newtonian Mechanics

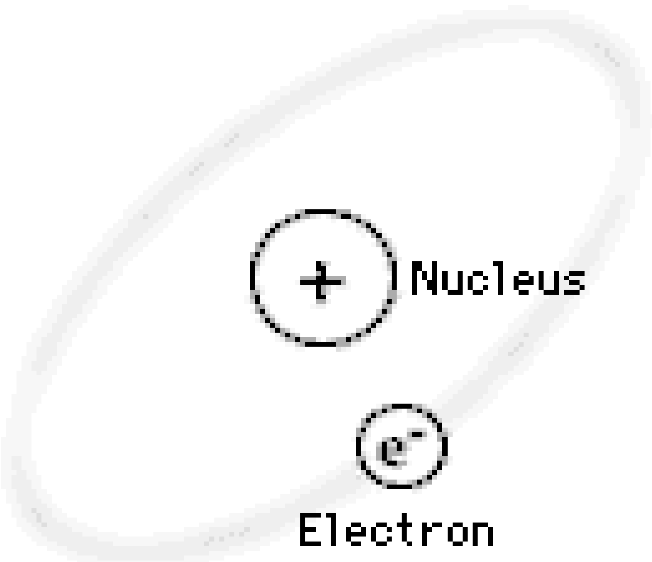
- Roughly speaking, the study of relation between a force and the acceleration it causes is called Newtonian Mechanics
- It applies to the motion of objects ranging in size from the very small (almost on the scale of atomic structure) to astronomical (galaxies and clusters of galaxies)
- However it does not apply to all situations, e.g.
  – If the speeds of the interacting bodies are very large — an appreciable fraction of the speed of light—we must replace Newtonian mechanics with **Einstein's special theory of relativity**, which holds at any speed, including those near the speed of light
  – If the interacting bodies are on the scale of atomic structure (for example, they might be electrons in an atom), we must replace Newtonian mechanics with **quantum mechanics**
- Newtonian mechanics is viewed as a special case of these two more comprehensive theories

Laws of Motion

- *If an object moves with uniform motion (constant velocity),no force is required for the motion to be maintained.*

  Moon-Earth system , Electron revolves around nucleus



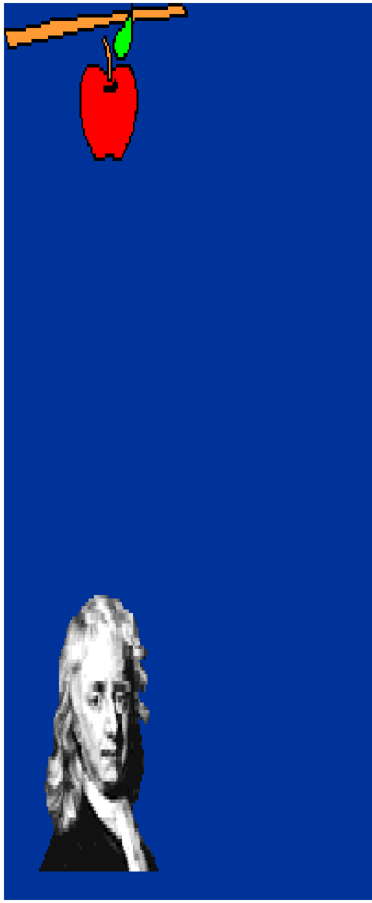


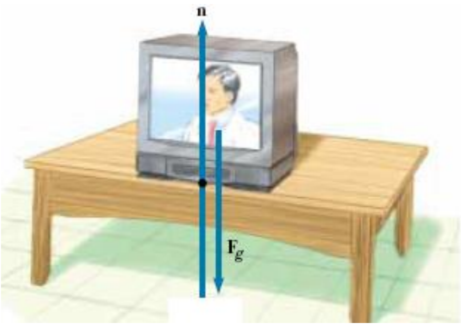
Laws of Motion

- *What happens when several forces act simultaneously on an object?*

The object accelerates only if the net force(total/resultant/unbalance), acting on it is not equal to zero.

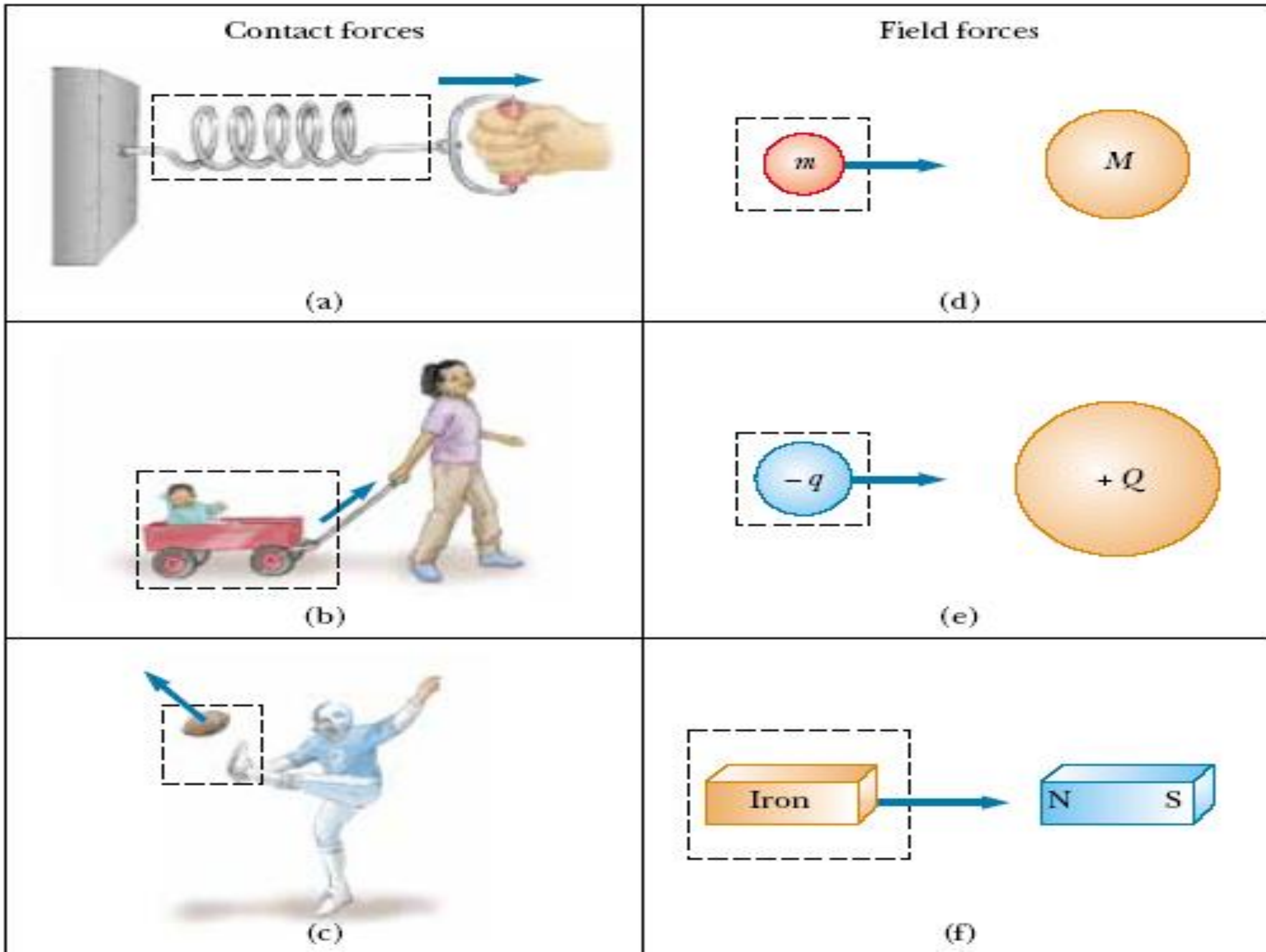
- *If the net force exerted on an object is zero, then the acceleration of the object is zero and its velocity remains constant. The object is said to be in equilibrium.*





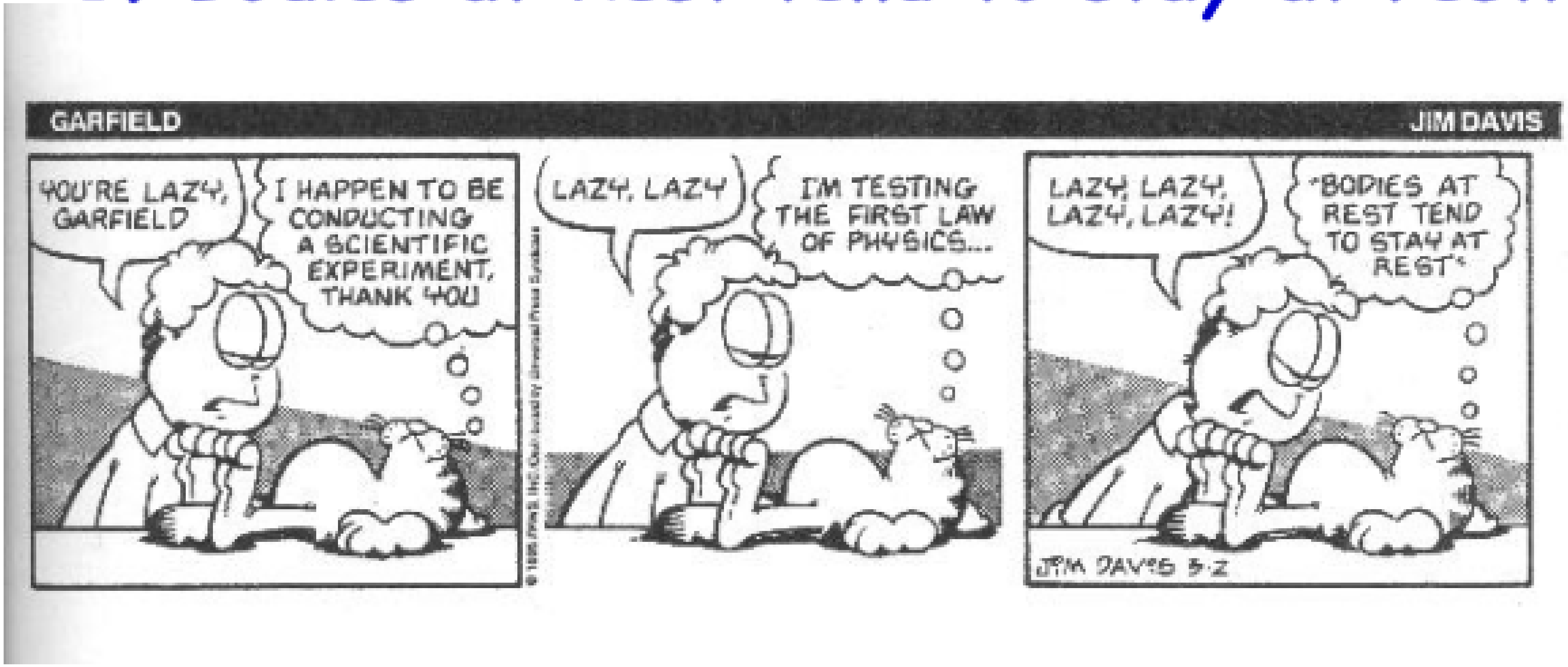
Classes of forces

- *Contact forces :*
- *Field Force / Action at a distance force*



First Law

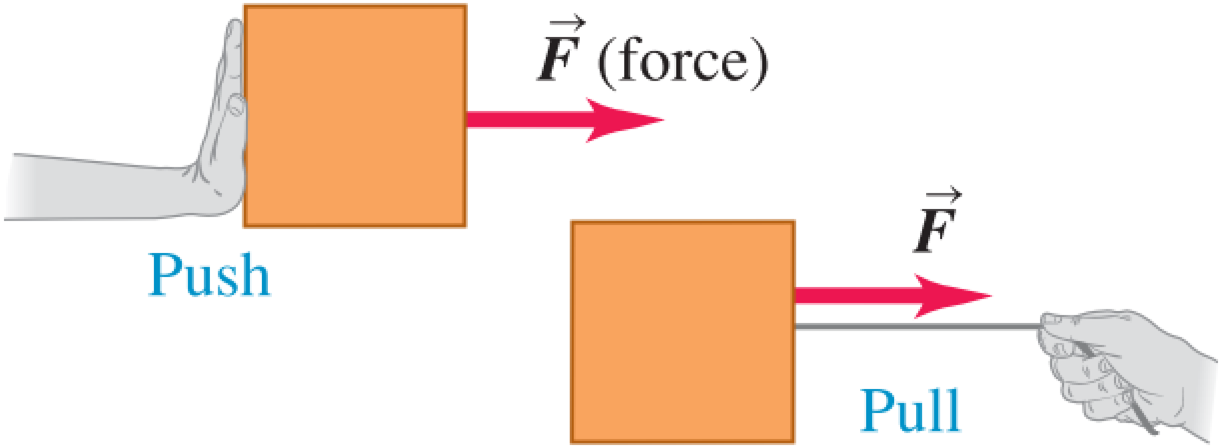
1. Bodies at Rest tend to stay at rest!



Not complete as above! Stays at constant velocity unless acted on by outside force!

Force

- A force is
  - a push or a pull
  - an interaction between two objects or between an object and its environment
  - a vector quantity, with magnitude and direction



Newton’s First Law

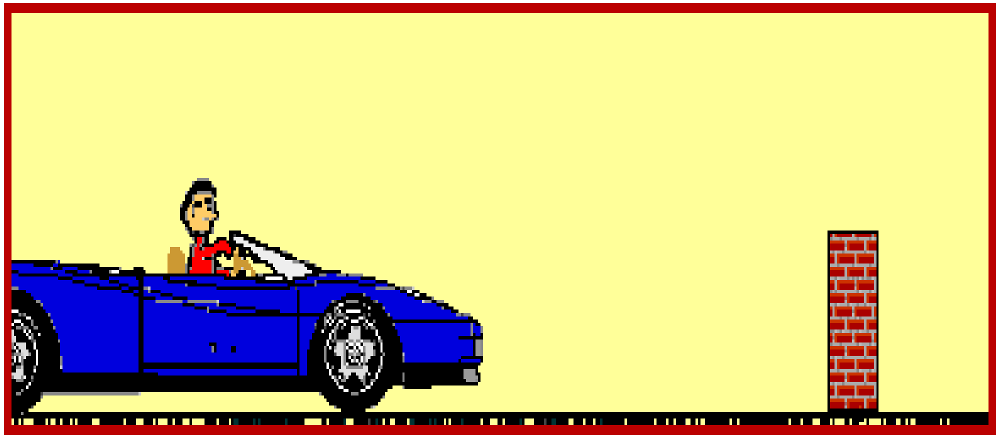
- If no net force acts on a body i.e.

$$\overrightarrow{F_{net}} = 0 \qquad \text{(body in equilibrium)}$$

  then the body’s moves with constant velocity (which may be **zero**) and zero acceleration
- There may be multiple forces acting on a body, but if their net force is zero, the body cannot accelerate
- The tendency of a body to keep moving once it is set in motion results from a property called **inertia**

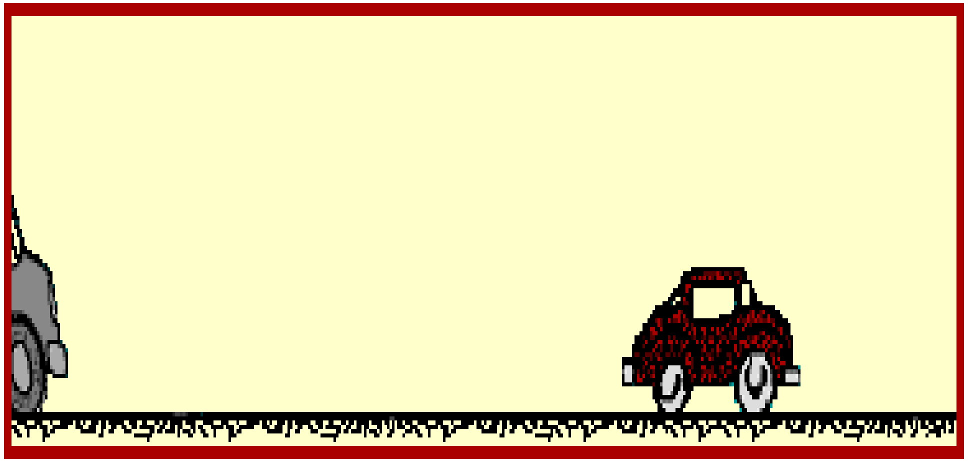
Inertia

The tendency of an object to resist any attempt to change its velocity is called the inertia of the object.



Don't let this be you. Wear seat belts.

Because of inertia, objects (including you) resist changes in their motion. When the car going 80 km/hour is stopped by the brick wall, your body keeps moving at 80 m/hour.



Principle of Superposition for Forces

- This means that when two or more forces act on a body, we can find their net force, or resultant force, by adding the individual forces vectorially
- A single force that has the magnitude and direction of the net force has the same effect on the body as all the individual forces together
- This fact is called the principle of superposition for forces

Decomposing a force into its component vectors

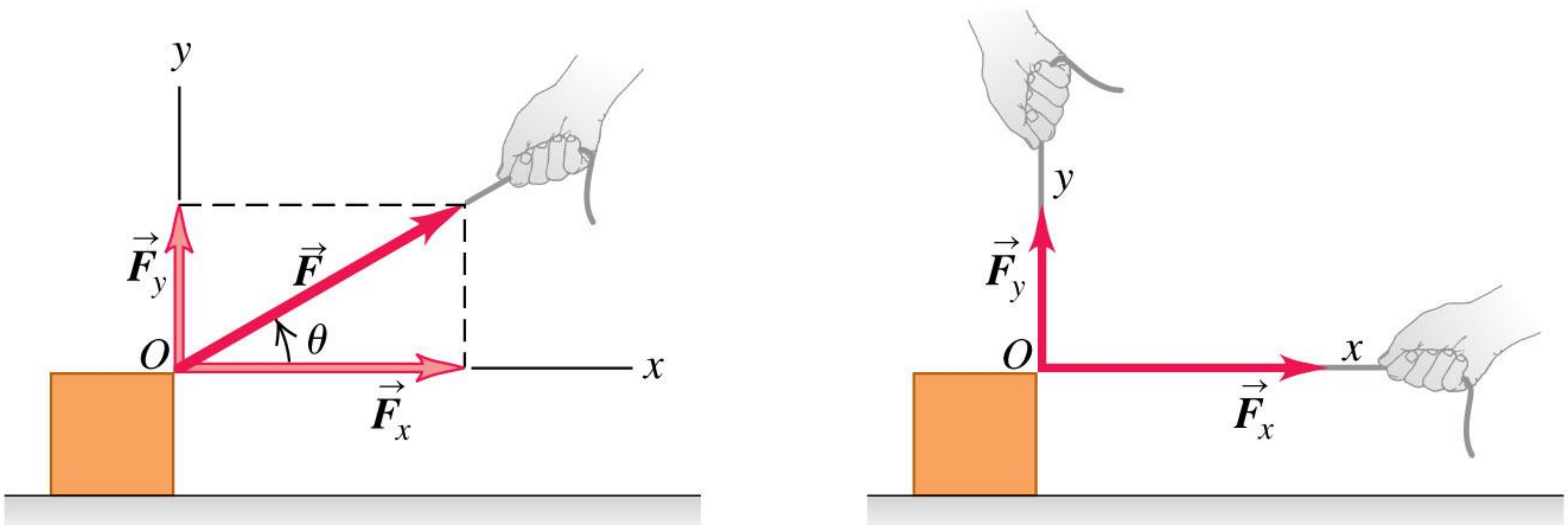
– Choose perpendicular *x* and *y* axes.

– F_x and F_y are the components of a force along these axes.

– Use trigonometry to find these force components.

(a) Component vectors: $\vec{F}_x$ and $\vec{F}_y$
Components: $F_x = F\cos\theta$ and $F_y = F\sin\theta$

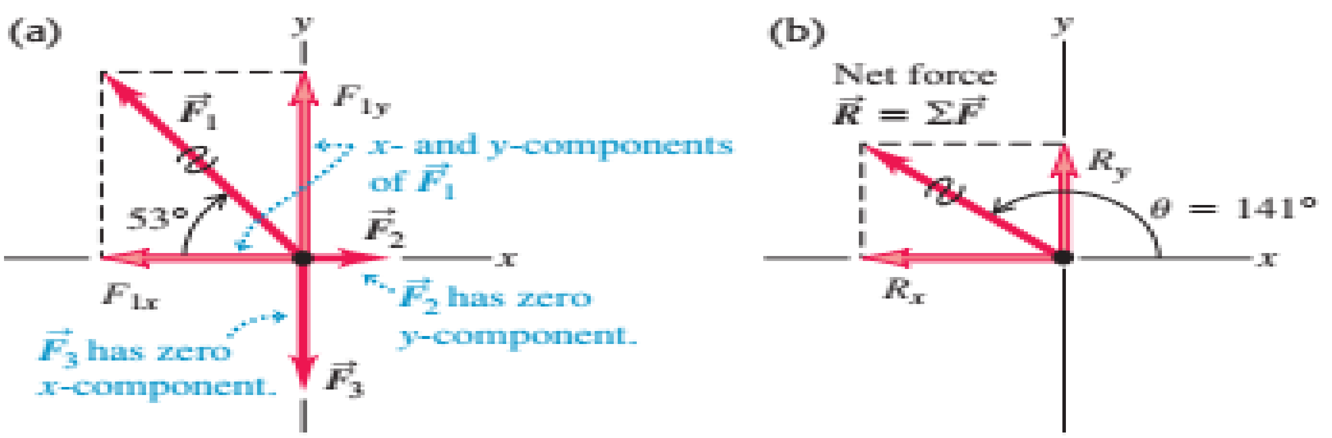
(b) Component vectors $\vec{F}_x$ and $\vec{F}_y$ together have the same effect as original force $\vec{F}$.



Example(Superposition of Forces)

Three professional wrestlers are fighting over a champion's belt. Figure 4.8a shows the horizontal force each wrestler applies to the belt, as viewed from above. The forces have magnitudes $F_1 = 250$ N, $F_2 = 50$ N, and $F_3 = 120$ N. Find the x- and y-components of the net force on the belt, and find its magnitude and direction.

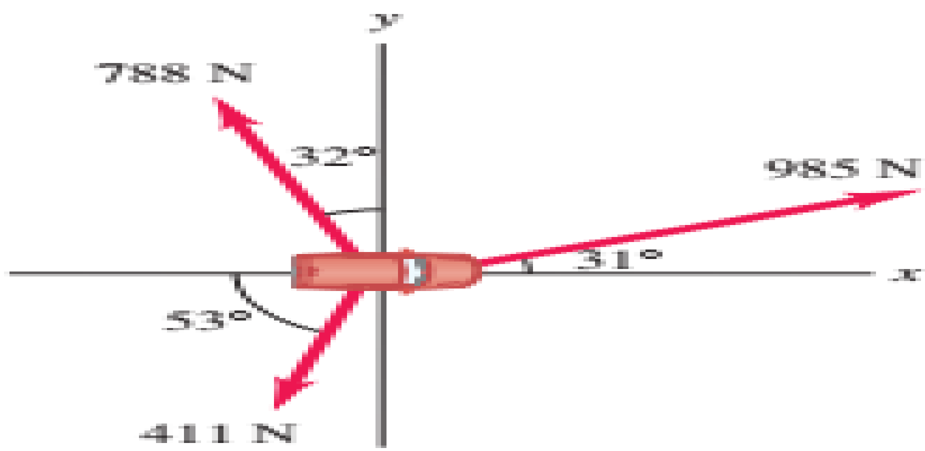
4.8 (a) Three forces acting on a belt. (b) The net force $\vec{R} = \sum\vec{F}$ and its components.



Example Problem

- Workmen are trying to free an SUV stuck in the mud. To extricate the vehicle, they use three horizontal ropes, producing the force vectors shown in Fig. E4.2. (a) Find the x- and y-components of each of the three pulls. (b) Use the components to find the magnitude and direction of the resultant of the three pulls

Figure E4.2



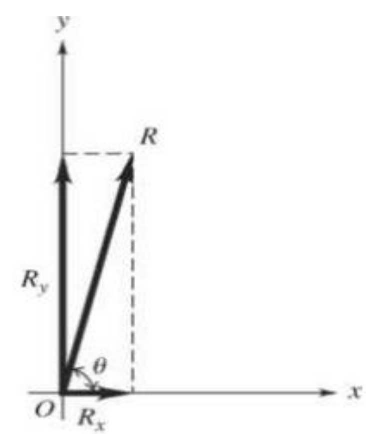
Solution

IDENTIFY: We know the magnitudes and directions of three vectors and want to use them to find their components, and then to use the components to find the magnitude and direction of the resultant vector.

SET UP: Let $F_1 = 985\ \text{N}$, $F_2 = 788\ \text{N}$, and $F_3 = 411\ \text{N}$. The angles θ that each force makes with the $+x$ axis are $\theta_1 = 31°$, $\theta_2 = 122°$, and $\theta_3 = 233°$. The components of a force vector are $F_x = F\cos\theta$ and $F_y = F\sin\theta$, and $R = \sqrt{R_x^2 + R_y^2}$ and $\tan\theta = \dfrac{R_y}{R_x}$.

EXECUTE: **(a)** $F_{1x} = F_1\cos\theta_1 = 844\ \text{N}$, $F_{1y} = F_1\sin\theta_1 = 507\ \text{N}$, $F_{2x} = F_2\cos\theta_2 = -418\ \text{N}$, $F_{2y} = F_2\sin\theta_2 = 668\ \text{N}$, $F_{3x} = F_3\cos\theta_3 = -247\ \text{N}$, and $F_{3y} = F_3\sin\theta_3 = -328\ \text{N}$.

(b) $R_x = F_{1x} + F_{2x} + F_{3x} = 179\ \text{N}$; $R_y = F_{1y} + F_{2y} + F_{3y} = 847\ \text{N}$. $R = \sqrt{R_x^2 + R_y^2} = 886\ \text{N}$; $\tan\theta = \dfrac{R_y}{R_x}$ so $\theta = 78.1°$. $\vec{\boldsymbol{R}}$ and its components are shown in Figure 4.2.



Mass

- It is an intrinsic characteristic that relates a force on the body to the resulting acceleration
- Intrinsic characteristic means a characteristic that automatically comes with the existence of the body

Mass:

- **Mass is that property of an object that specifies how much inertia the object has.**
- **The greater the mass of an object, the less that object accelerates under the action of an applied force.**

$$\frac{m_1}{m_2} \equiv \frac{a_2}{a_1}$$

- **Mass is an inherent property of an object and is independent of the object's surroundings and of the method used to measure it.**
- **Mass is a scalar quantity.**

Weight :

- **The weight of an object is equal to the magnitude of the gravitational force exerted on the object and varies with location.**

$$F = mg$$

- **For example, a person who weighs 180 lb on the Earth weighs only about 30 lb on the Moon.**
- **On the other hand, the mass of a body is the same everywhere: an object having**
- **a mass of 2 kg on the Earth also has a mass of 2 kg on the Moon.**
- **Weight is a vector quantity .**

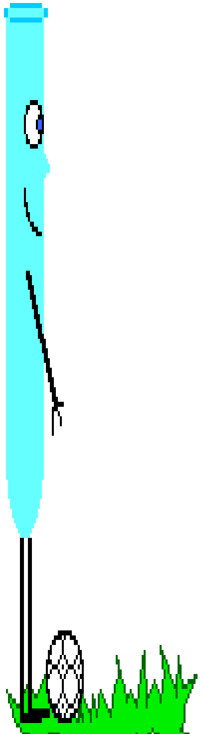
Newton's Second Law

The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass.

$$\sum \mathbf{F} = m\mathbf{a}$$

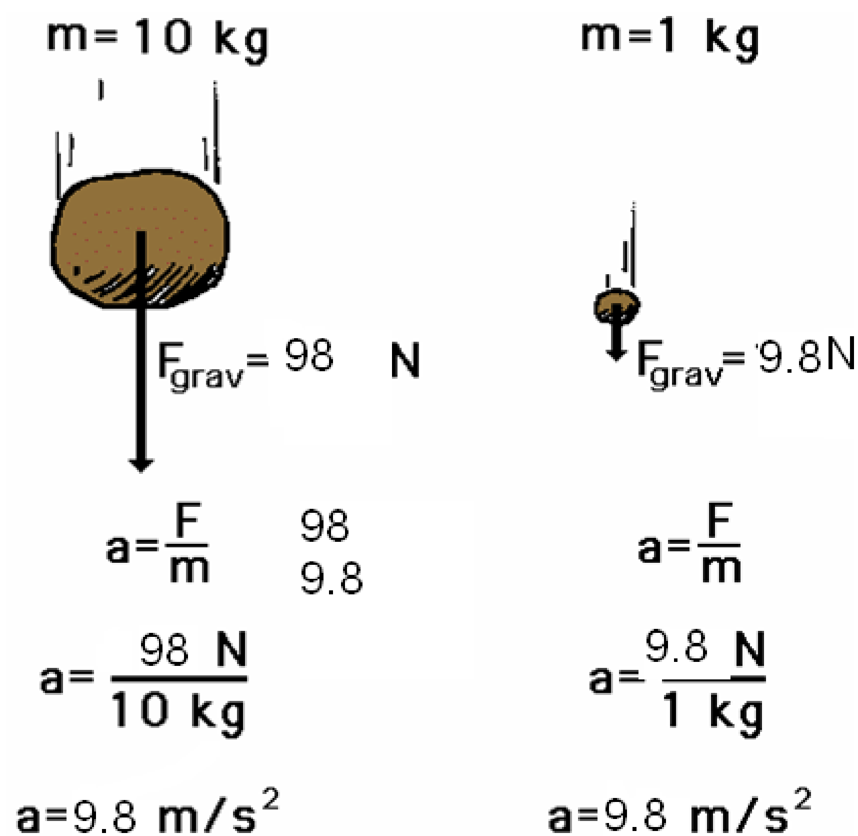
$$\sum F_x = ma_x \qquad \sum F_y = ma_y \qquad \sum F_z = ma_z$$

- *When mass is in kilograms and acceleration is in m/s/s, the unit of force is in Newtons (N).*
- *One Newton is equal to the force required to accelerate one kilogram of mass at one meter/second/second*



Newton's 2nd Law proves that different masses accelerate to the earth at the same rate, but with different forces.

- We know that objects with different masses accelerate to the ground at the same rate.
- However, because of the 2nd Law we know that they don't hit the ground with the same force.



F = ma

98 N = 10 kg x 9.8 m/s/s

F = ma

9.8 N = 1 kg x 9.8 m/s/s

Newton's Second Law

- The net force on a body is equal to the product of the body's mass and its acceleration

$$\overrightarrow{F_{net}} = m\vec{a}$$

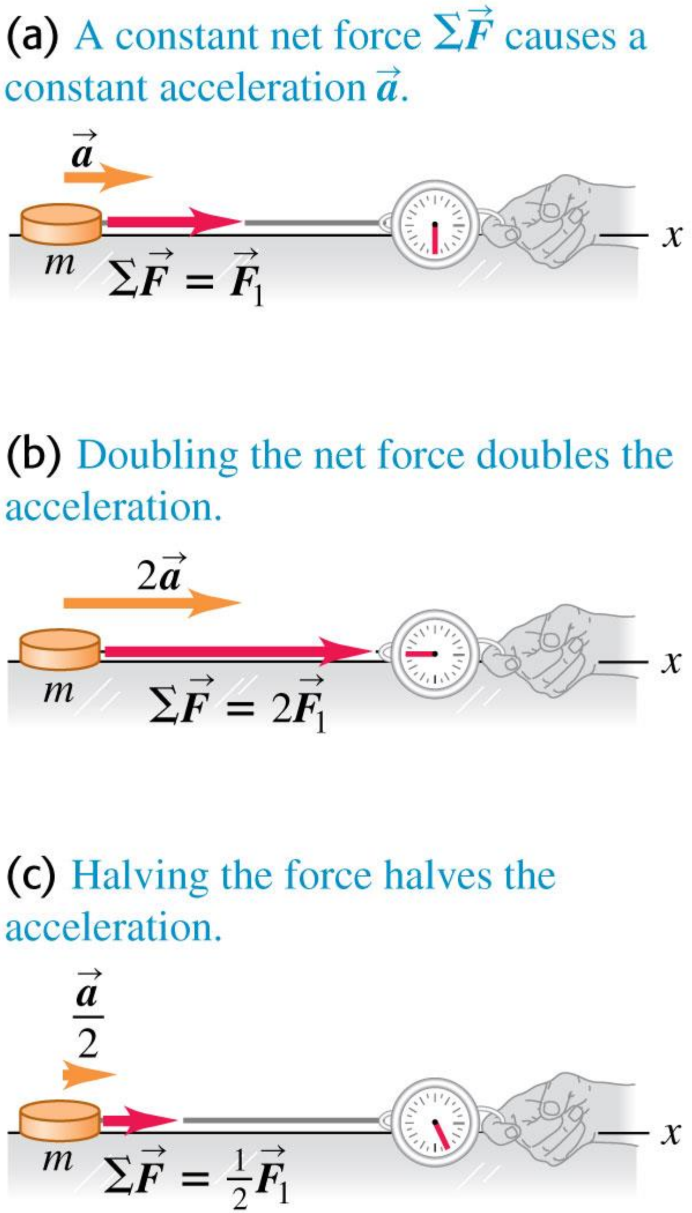
- This simple equation requires;
  - We must be certain about which body we are applying it to
  - F_{net} must be the vector sum of all the forces that act on that body. Only forces that act on that body are to be included in the vector sum, not forces acting on other bodies that might be involved in the given situation

$$F_{\text{net},x} = ma_x, \quad F_{\text{net},y} = ma_y, \quad \text{and} \quad F_{\text{net},z} = ma_z$$

  - The acceleration component along a given axis is caused only by the sum of the force components along that same axis, and not by force components along any other axis

Force and acceleration

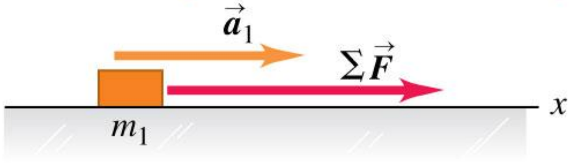
- The acceleration $\vec{a}$ of an object is directly proportional to the net force $\Sigma\vec{F}$ on the object.



Mass and acceleration

- The acceleration of an object is inversely proportional to the object’s mass if the net force remains fixed.

(a) A known force $\Sigma\vec{F}$ causes an object with mass m_1 to have an acceleration $\vec{a}_1$.



(b) Applying the same force $\Sigma\vec{F}$ to a second object and noting the acceleration allow us to measure the mass.

(c) When the two objects are fastened together, the same method shows that their composite mass is the sum of their individual masses.

Newton's 2nd Law

4.7 •• A 68.5-kg skater moving initially at 2.40 m/s on rough horizontal ice comes to rest uniformly in 3.52 s due to friction from the ice. What force does friction exert on the skater?

General Properties

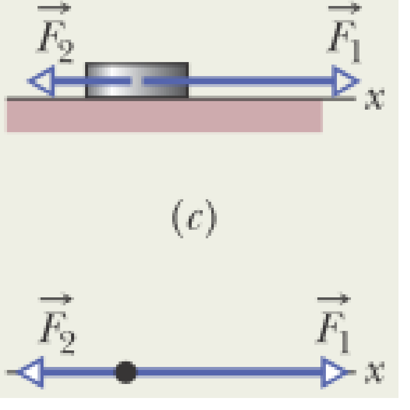
- Units Int'l System English
  - Acceleration: m/s^2 and ft/sec^2
  - Mass: kilograms (1000 grams) and slugs …
  - Force: Newtons …………………….and pounds (lbs)

$$\vec{F} = m\vec{a}$$

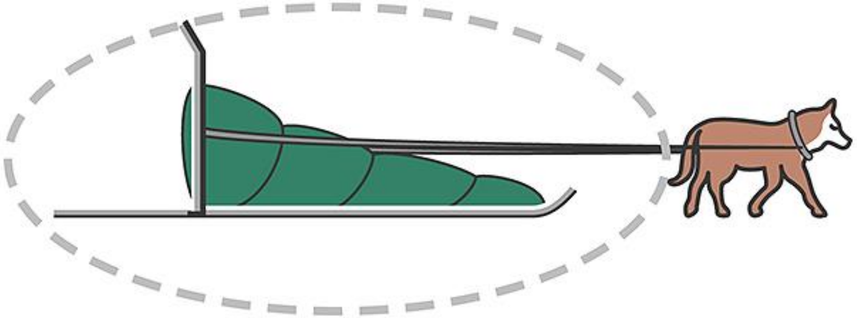
- Properties of Force
  - Vector
    - Since mass is <u>scalar</u> property intrinsic to a body
    - Acceleration is a <u>vector</u>
  - Typically, there are <u>many</u> forces on a body
  - If the vector sum of all forces is zero, body does not accelerate
  - And *vice versa*

Free Body Diagram

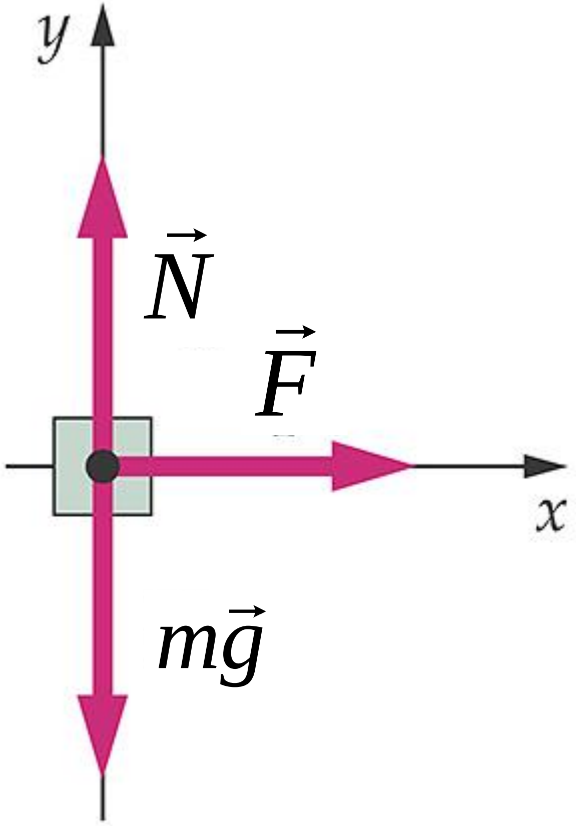
- The diagram in which the only body shown is the one for which we are summing forces
- The body is represented with a dot
- Also, each force on the body is drawn as a vector arrow with its tail on the body
- A coordinate system is usually included, and the acceleration of the body is sometimes shown with a vector arrow (labeled as an acceleration)



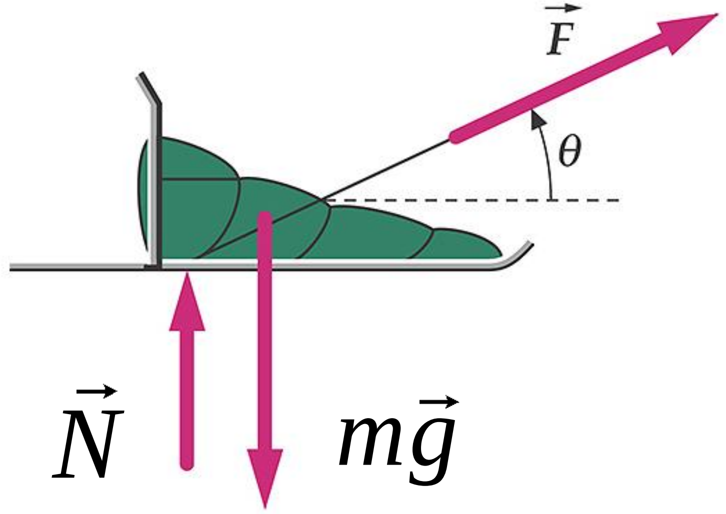
Free Body Diagram

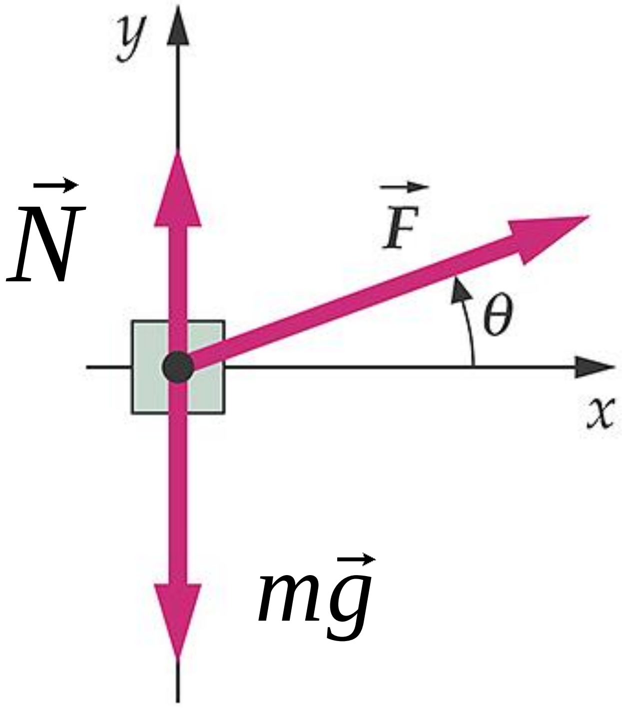


(a)



Same problem but the applied force is angled up





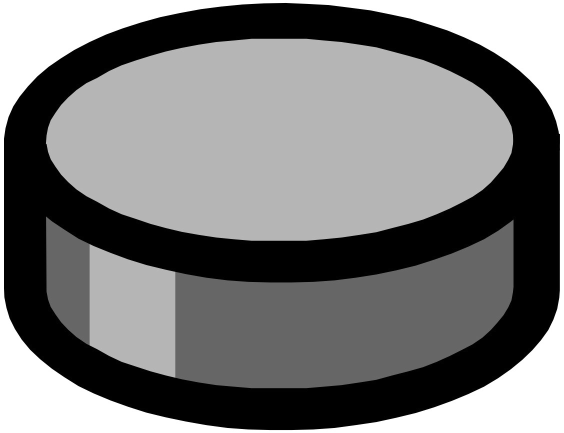
➢Types of Forces

Contact Forces	**Action-at-a-Distance Forces**
Frictional Force	Gravitational Force
Tension Force	Electrical Force
Normal Force	Magnetic Force
Air Resistance Force	
Applied Force	
Spring Force	

Obviously Gravitational and Electric and the Magnetic Forces are the Fundamental Forces where as all contact Forces are the manifestation of fundamental forces , Let us see how.

Friction

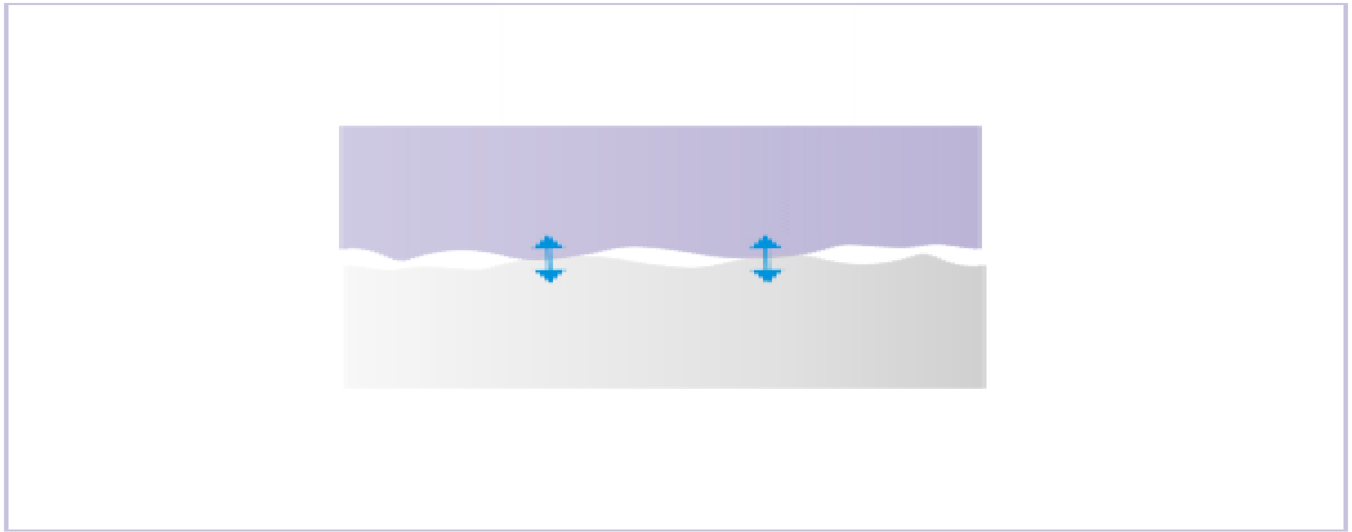
- Friction causes an object to slow down and stop.
- Since the amount of energy stays constant, the energy becomes heat.



➢Friction Force F_{frict}

The friction force is the force exerted by a surface as an object moves across it or makes an effort to move across it. The maximum amount of friction force that a surface can exert upon an object can be calculated using the formula below:

$$F_{frict} = \mu \bullet F_{norm}$$



Frictional Forces

Friction: a contact force *parallel* to the contact surfaces.

Static friction acts to prevent objects from sliding.

$$f_s^{max} = \mu_s N$$

Kinetic friction acts to make sliding objects slow down. Sometimes called Dynamic friction.

$$f_d = \mu_d N$$

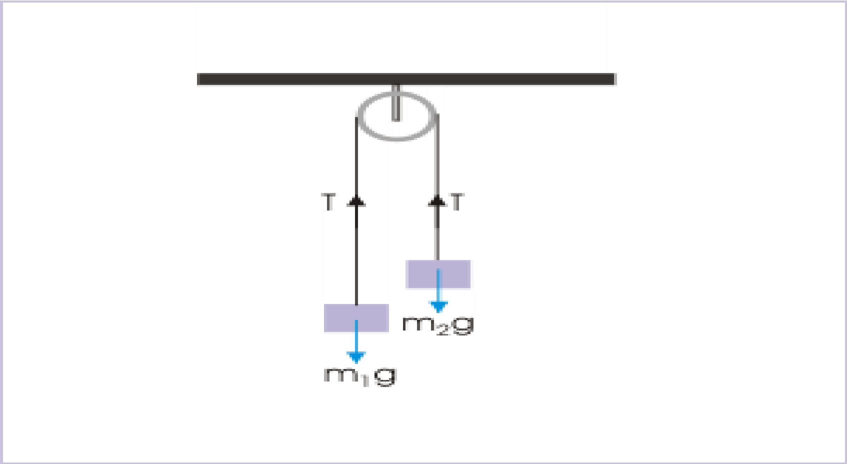
Tension

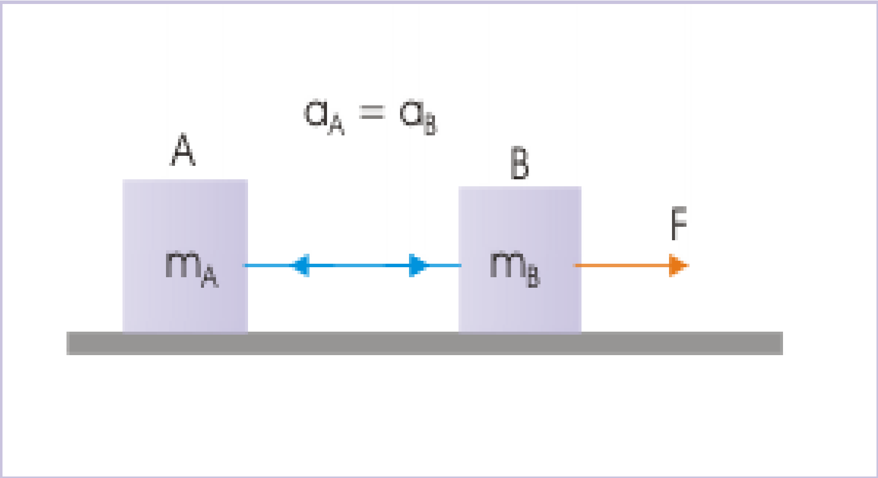
This is the force transmitted through a “rope” from one end to the other.

An **ideal** cord has zero mass, does not stretch, and the tension is the same throughout the cord.

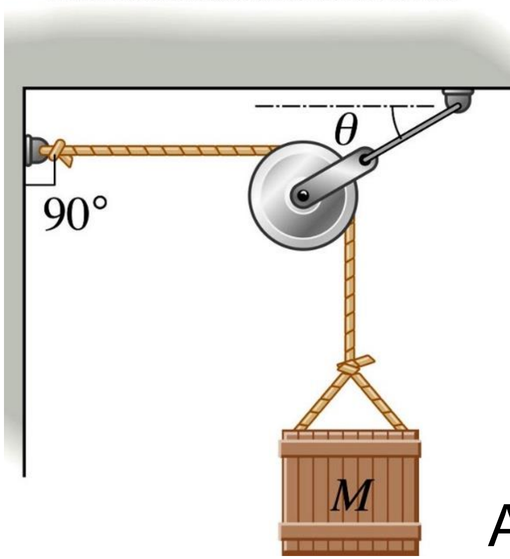
➢Tension Force F_{tens}

The tension force is the force that is transmitted through a string, rope, cable or wire when it is pulled tight by forces acting from opposite ends. The tension force is directed along the length of the wire and pulls equally on the objects on the opposite ends of the wire.

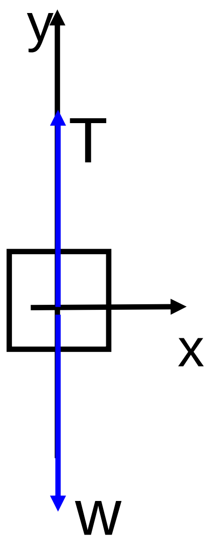




Example (text problem 4.77): A pulley is hung from the ceiling by a rope. A block of mass M is suspended by another rope that passes over the pulley and is attached to the wall. The rope fastened to the wall makes a right angle with the wall. Neglect the masses of the rope and the pulley. Find the tension in the rope from which the pulley hangs and the angle θ.



FBD for the mass M



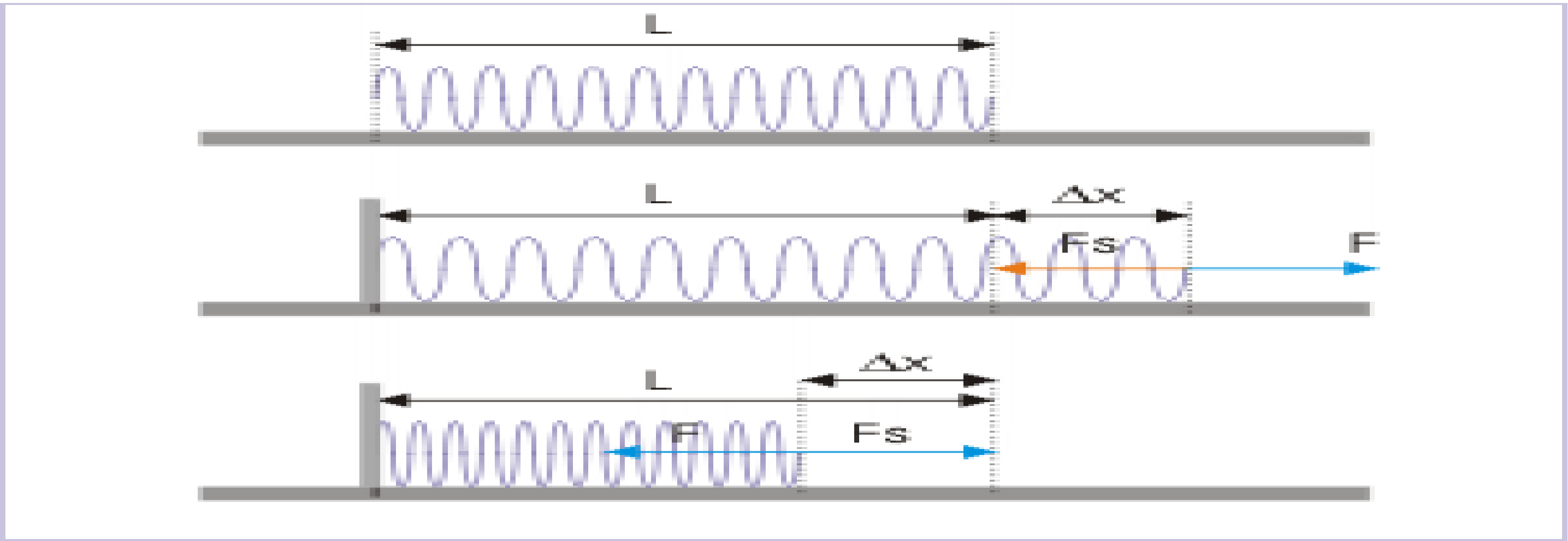
Apply Newton's 2nd Law to the mass M.

$$\sum F_y = T - w = 0$$

$$T = w = Mg$$

➢Spring Force F_{spring}

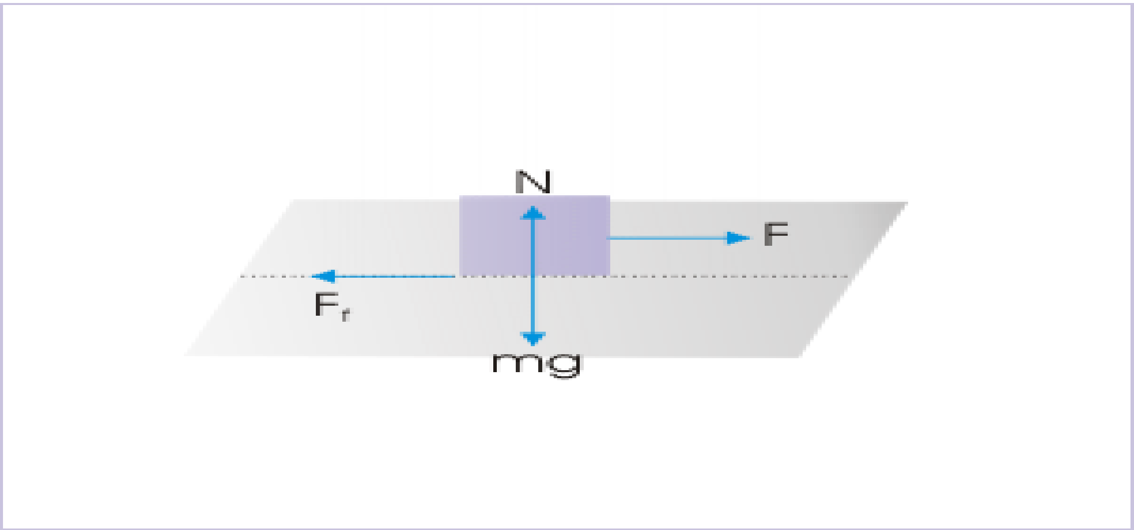
The spring force is the force exerted by a compressed or stretched spring upon any object that is attached to it. An object that compresses or stretches a spring is always acted upon by a force that restores the object to its rest or equilibrium position.



➢Normal Force

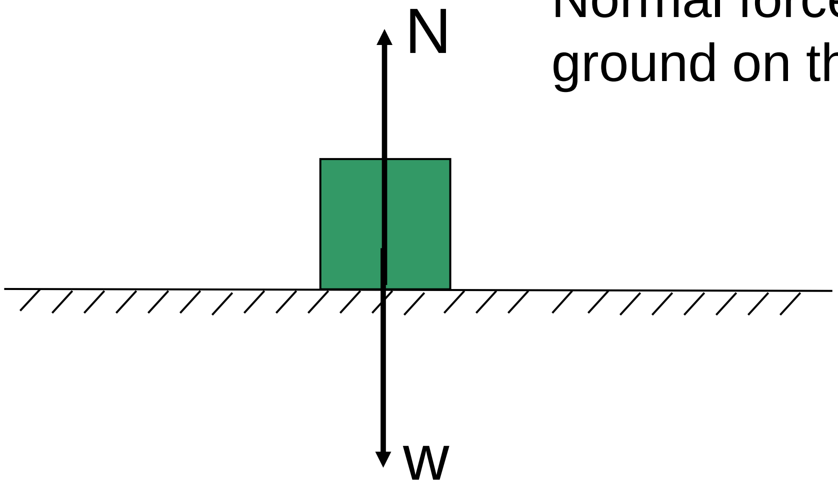
F_{norm}

The normal force is the support force exerted upon an object that is in contact with another stable object. For example, if a book is resting upon a surface, then the surface is exerting an upward force upon the book in order to support the weight of the book. On occasions, a normal force is exerted horizontally between two objects that are in contact with each other. For instance, if a person leans against a wall, the wall pushes horizontally on the person.

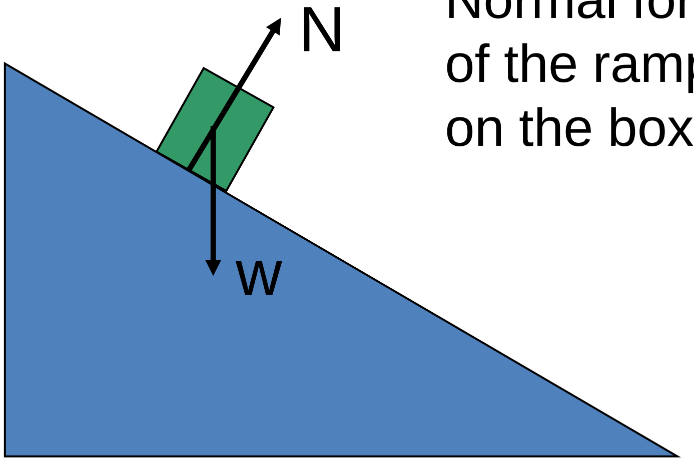


Normal Forces

Normal force: this force acts in the direction perpendicular to the contact surface.



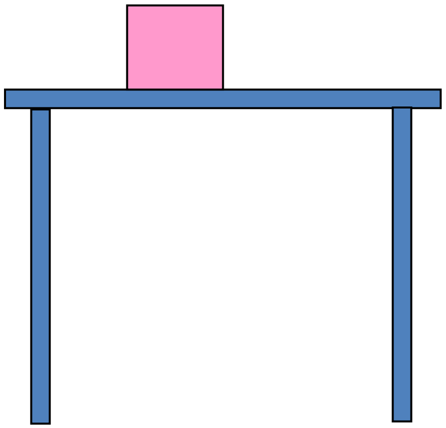
Normal force of the ground on the box



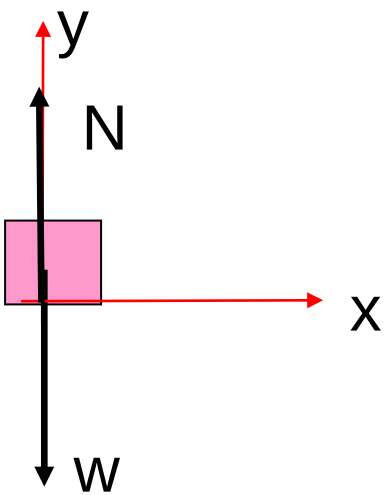
Normal force of the ramp on the box

Normal Forces

Example: Consider a box on a table.



FBD for box



Apply Newton's 2nd law

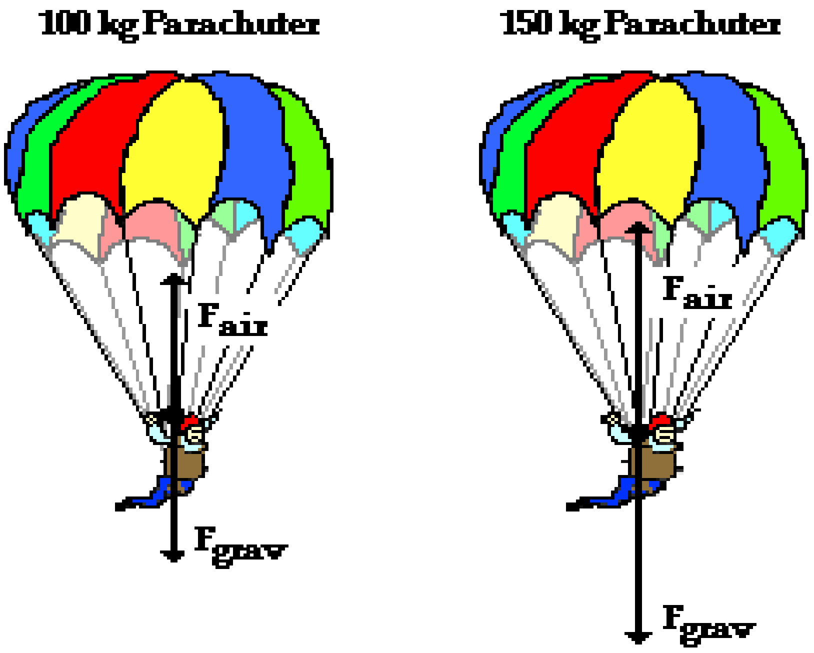
$$\sum F_y = N - w = 0$$

So that $N = w = mg$

This just says the magnitude of the normal force equals the magnitude of the weight; they are not Newton's third law interaction partners.

➢Air Resistance Force F_{air}

The air resistance is a special type of frictional force that acts upon objects as they travel through the air. The force of air resistance is often observed to oppose the motion of an object. This force will frequently be neglected due to its negligible magnitude (and due to the fact that it is mathematically difficult to predict its value). It is most noticeable for objects that travel at high speeds (e.g., a skydiver or a downhill skier) or for objects with large surface areas.

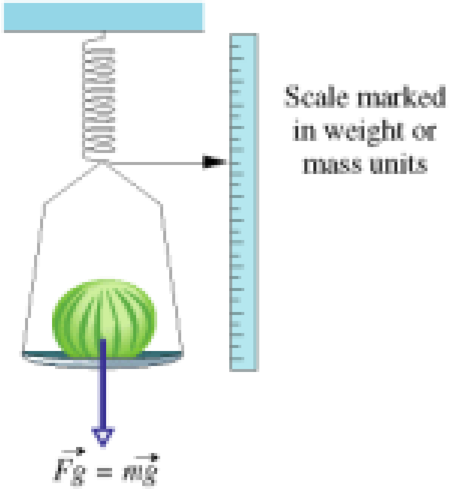


➢Applied Force F_{app}

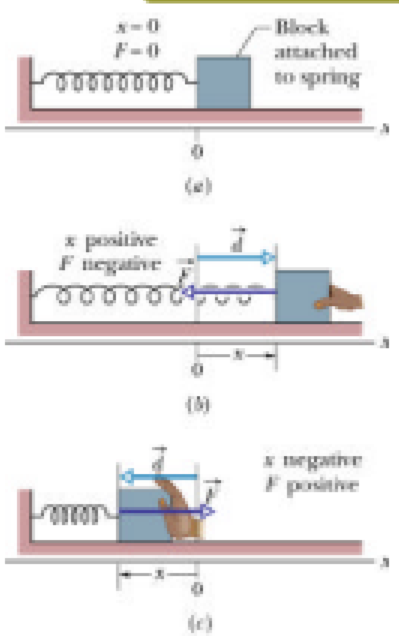
An applied force is a force that is applied to an object by a person or another object. If a person is pushing a desk across the room, then there is an applied force acting upon the object. The applied force is the force exerted on the desk by the person.

So we conclude that basically there are four fundamental forces in the Universe and we do experience only two of them in our every day life , regardless what name we give to particular force.

Illustrative Forces 1



- **WEIGHT** (gravitational force)
  - Gravity pulls everything down, but is resisted by any contact with a surface
  - If we <u>let it go</u>: *a=g , so it follows that the grav force must be F_g=mg*



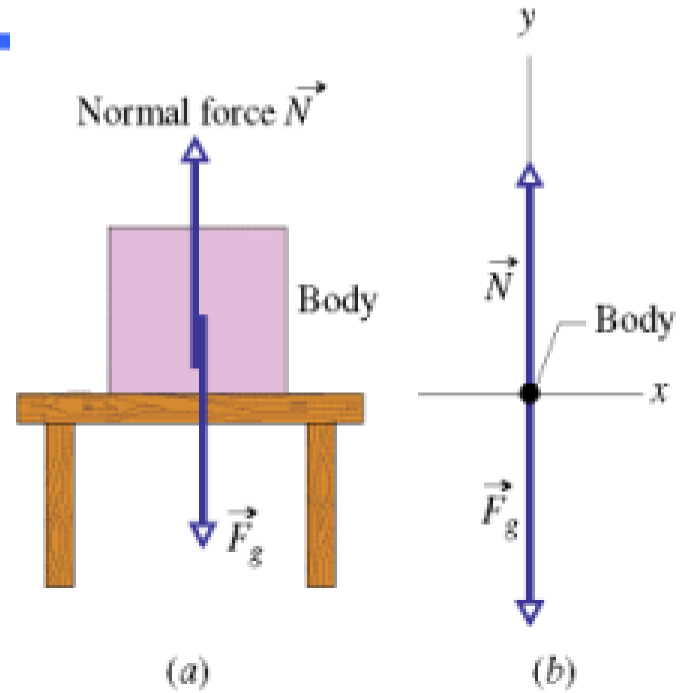
- <u>**Spring Force:**</u> force produced by <u>spring (or flexible material)</u> opposing extension or compression

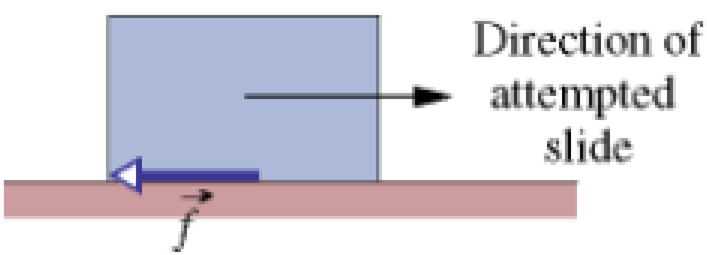
$$F_x = -kx$$

Illustrative Forces 2

- **Normal Force:** acts perpendicular to solid surfaces
  - prevents solid bodies from penetrating other solid bodies

If body is at rest, then $N = F_g = mg$



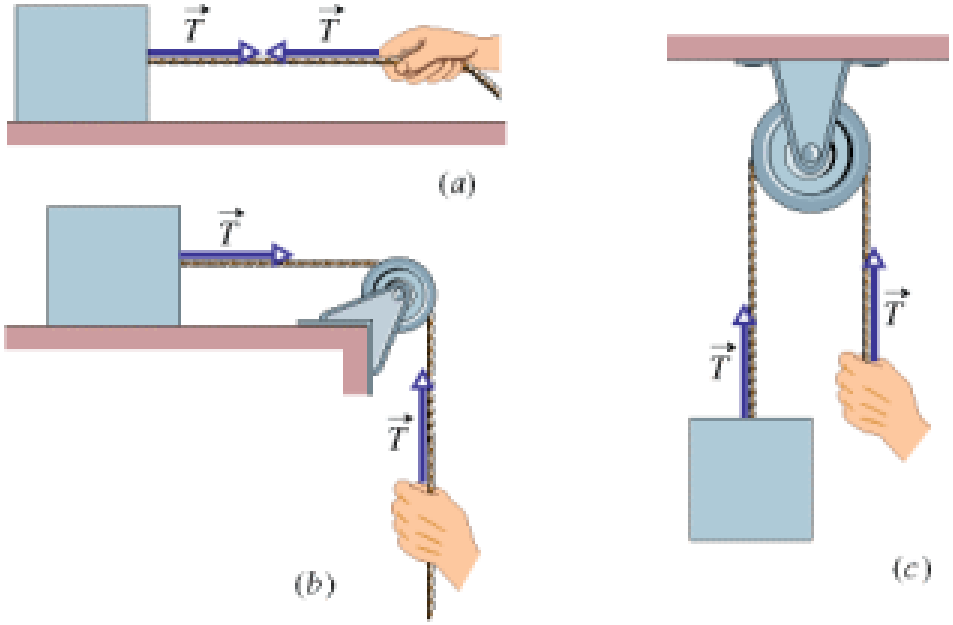


FRICTION

- **Friction**: HORIZONTAL force exerted by one surface on another
  - varies with type of surface …there are even *frictionless* surfaces
  - can be static or kinetic
  - STAY TUNED!

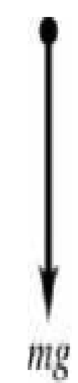
Illustrative Forces 3

TENSION



- **Tension**: Force exerted by string, rope, cable, etc.
  - typically the force is exerted by the cord on the body to which it is attached
  - the same force, in both directions, exists at all points in the cord

4.26 • An athlete throws a ball of mass m directly upward, and it feels no appreciable air resistance. Draw a free-body diagram of this ball while it is free of the athlete's hand and (a) moving upward; (b) at its highest point; (c) moving downward. (d) Repeat parts (a), (b), and (c) if the athlete throws the ball at a 60° angle above the horizontal instead of directly upward.

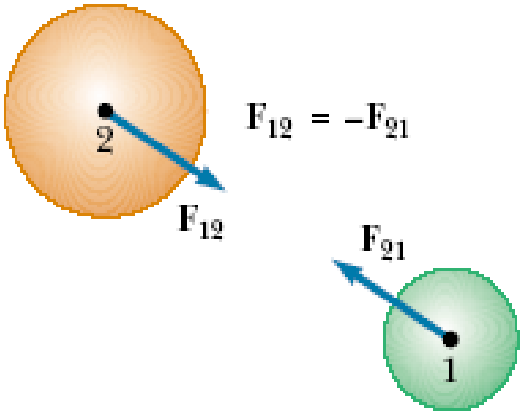


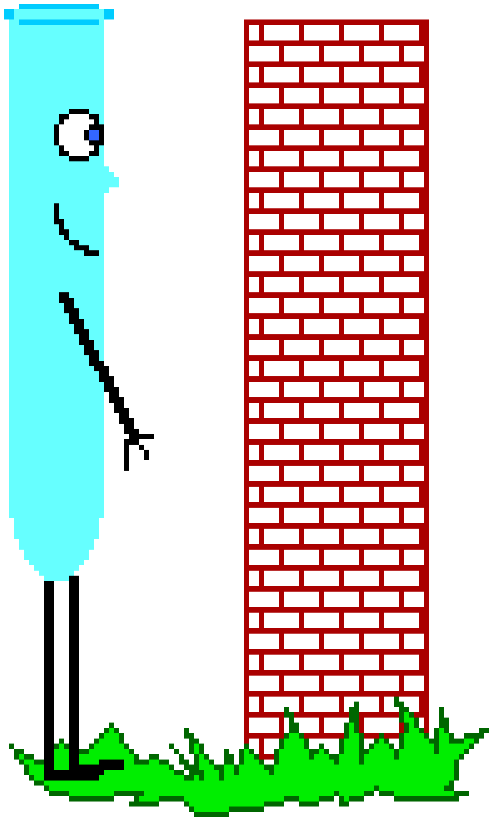
Newton's Third Law

If two objects interact, the force $\mathbf{F}_{12}$ exerted by object 1 on object 2 is equal in magnitude to and opposite in direction to the force $\mathbf{F}_{21}$ exerted by object 2 on object 1:

$$\mathbf{F}_{12} = -\mathbf{F}_{21}$$

For every action, there is an equal and opposite reaction.





Newton's 3rd Law in Nature

- Consider the propulsion of a fish through the water. A fish uses its fins to push water backwards. In turn, the water *reacts* by pushing the fish forwards, propelling the fish through the water.
- The size of the force on the water equals the size of the force on the fish; the direction of the force on the water (backwards) is opposite the direction of the force on the fish (forwards).

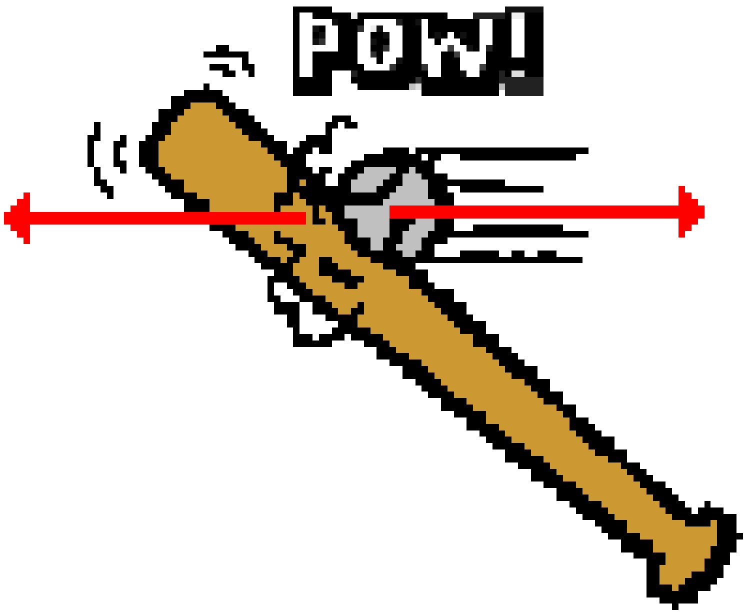
3rd Law

Flying gracefully through the air, birds depend on Newton's third law of motion. As the birds push down on the air with their wings, the air pushes their wings up and gives them lift.

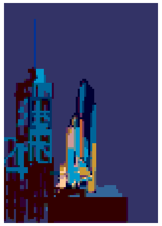
- *Consider the flying motion of birds. A bird flies by use of its wings. The wings of a bird push air downwards. In turn, the air reacts by pushing the bird upwards.*
- *The size of the force on the air equals the size of the force on the bird; the direction of the force on the air (downwards) is opposite the direction of the force on the bird (upwards).*
- *Action-reaction force pairs make it possible for birds to fly.*

Other examples of Newton's Third Law

- The baseball forces the bat to the left (an action); the bat forces the ball to the right (the reaction).



3^{rd} Law



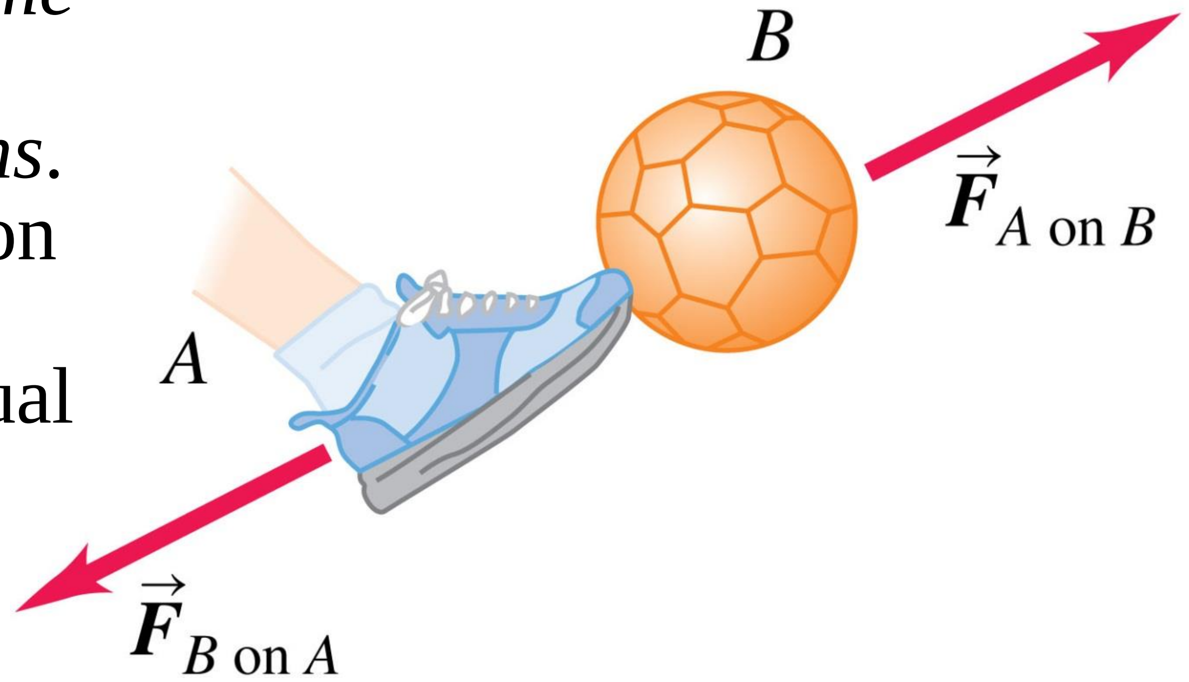
The reaction of a rocket is an application of the third law of motion. Various fuels are burned in the engine, producing hot gases.

The hot gases push against the inside tube of the rocket and escape out the bottom of the tube. As the gases move downward, the rocket moves in the opposite direction.

Newton's Third Law

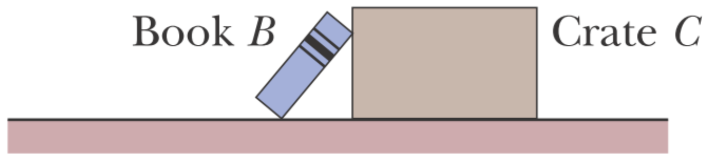
- If you exert a force on a body, the body always exerts a force (the "reaction") back upon you.
- Figure 4.25 shows "an action-reaction pair."

- A force and its reaction force have the *same magnitude but opposite directions*. These forces act on *different bodies*. [Follow Conceptual Example 4.8]

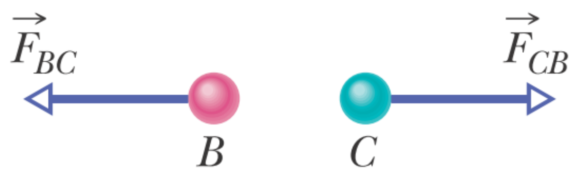


Newton’s Third Law

- When two bodies interact, the forces on the bodies from each other are always equal in magnitude and opposite in direction
- These forces between two interacting bodies a third-law force pair



(a)



For the book and crate, we can write this law as the scalar relation

$$F_{BC} = F_{CB} \qquad \text{(equal magnitudes)}$$

or as the vector relation

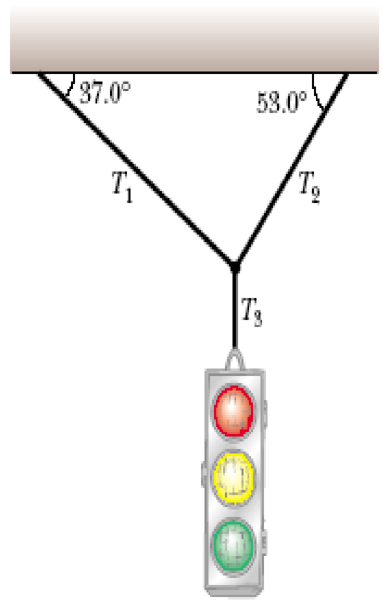
$$\vec{F}_{BC} = -\vec{F}_{CB} \qquad \text{(equal magnitudes and opposite directions)}$$

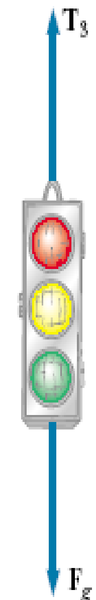
4.21 • BIO World-class sprinters can accelerate out of the starting blocks with an acceleration that is nearly horizontal and has magnitude 15 m/s^2. How much horizontal force must a 55-kg sprinter exert on the starting blocks during a start to produce this acceleration? Which body exerts the force that propels the sprinter: the blocks or the sprinter herself?

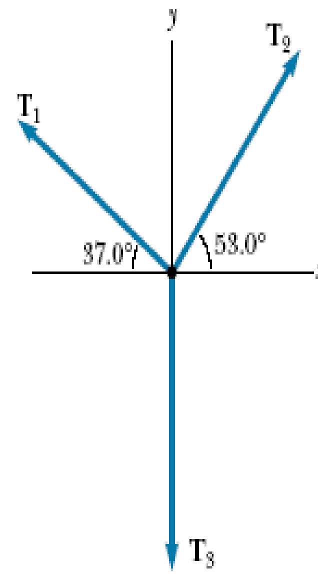
APPLICATIONS OF NEWTON'S LAWS

A Traffic Light at Rest

A traffic light weighing 125 N hangs from a cable tied to two other cables fastened to a support. The upper cables make angles of 37.0° and 53.0° with the horizontal. Find the tension in the three cables.







Force	x Component	y Component
$\mathbf{T}_1$	$-T_1 \cos 37.0°$	$T_1 \sin 37.0°$
$\mathbf{T}_2$	$T_2 \cos 53.0°$	$T_2 \sin 53.0°$
$\mathbf{T}_3$	0	-125 N

$$\sum F_x = -T_1 \cos 37.0° + T_2 \cos 53.0° = 0$$

$$\sum F_y = T_1 \sin 37.0° + T_2 \sin 53.0° + (-125\ N) = 0$$

$$T_1 \sin 37.0° + (1.33 T_1)(\sin 53.0°) - 125\text{ N} = 0$$

$$T_2 = T_1 \left(\frac{\cos 37.0°}{\cos 53.0°} \right) = 1.33 T_1$$

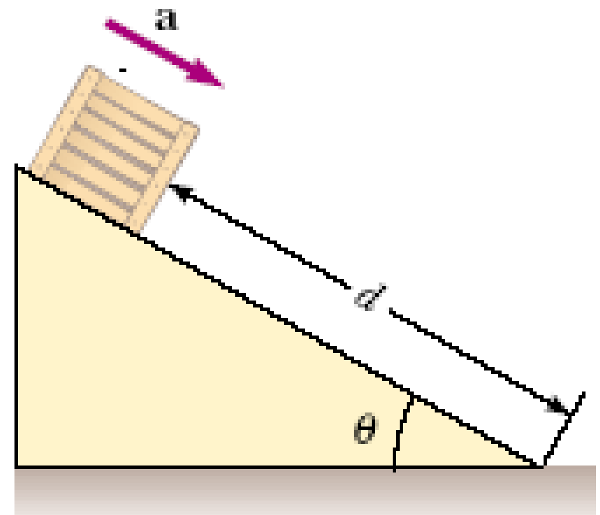
$$T_1 = \boxed{75.1\text{ N}}$$

$$T_3 = F_g = \boxed{125\text{ N.}}$$

$$T_2 = 1.33 T_1 = \boxed{99.9\text{ N}}$$

Crate on a Frictionless

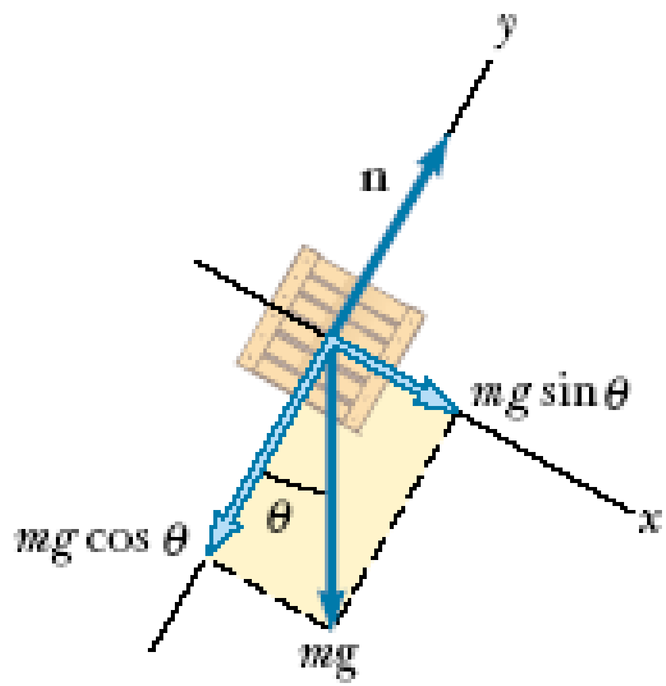
A crate of mass m is placed on a frictionless inclined plane of angle θ. (a) Determine the acceleration of the crate after it is released.



$$\sum F_x = mg\sin\theta = ma_x$$

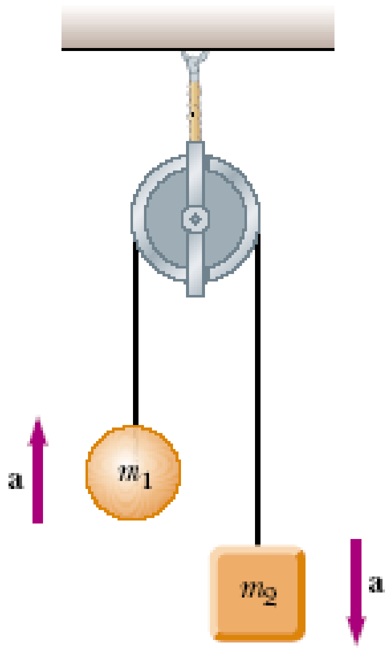
$$\sum F_y = n - mg\cos\theta = 0$$

$$a_x = g\sin\theta$$



Atwood's Machine

When two objects of unequal mass are hung vertically over a frictionless pulley of negligible mass, Determine the magnitude of the acceleration of the two objects and the tension in the lightweight cord.



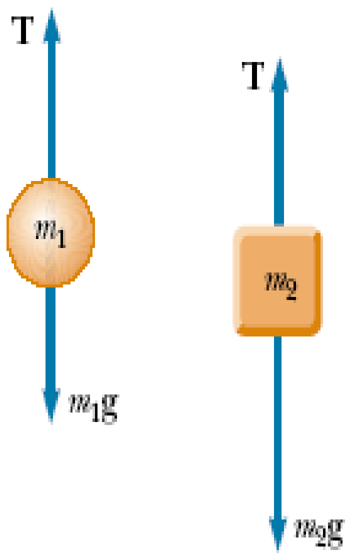
$$\sum F_y = m_2 g - T = m_2 a_y$$

$$\sum F_y = T - m_1 g = m_1 a_y$$

$$-m_1 g + m_2 g = m_1 a_y + m_2 a_y$$

$$a_y = \left(\frac{m_2 - m_1}{m_1 + m_2}\right) g$$

$$T = \left(\frac{2 m_1 m_2}{m_1 + m_2}\right) g$$



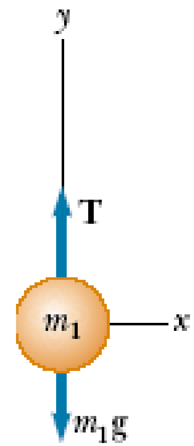
Special Cases When $m_1 = m_2$, then $a_y = 0$ and $T = m_1 g$, as we would expect for this balanced case. If $m_2 \gg m_1$, then $a_y \approx g$ (a freely falling body) and $T \approx 2 m_1 g$.

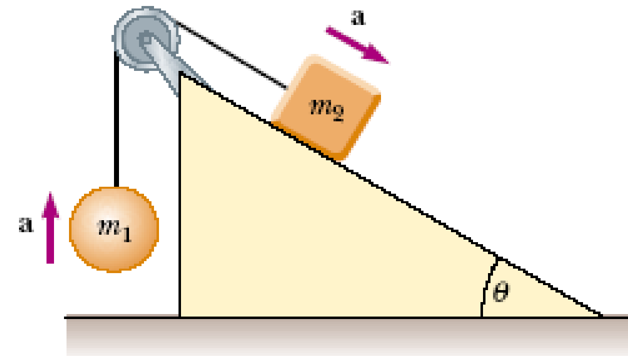
Acceleration of Two Objects Connected by a Cord

A ball of mass *m1 and a block of mass m2 are attached by a* lightweight cord that passes over a frictionless pulley of negligible mass, as shown in Figure. The block lies on a frictionless incline of angle . Find the magnitude of the acceleration of the two objects and the tension in the cord.

$$\sum F_x = 0$$

$$\sum F_y = T - m_1 g = m_1 a_y = m_1 a$$



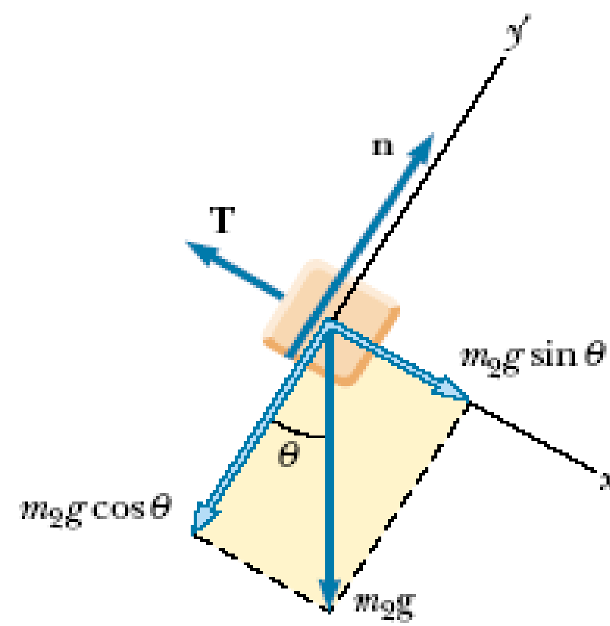


$$\sum F_{x'} = m_2 g \sin\theta - T = m_2 a_{x'} = m_2 a$$

$$\sum F_{y'} = n - m_2 g \cos\theta = 0$$

$$a = \frac{m_2 g \sin\theta - m_1 g}{m_1 + m_2}$$

$$T = \frac{m_1 m_2 g(\sin\theta + 1)}{m_1 + m_2}$$



Disclaimer

- Pictures and
  - Halliday & Resnick, Principles of Physics Extended, 10th Edition, Wiley, June 2010
  - Young & Freedman, *University Physics With Modern Physics,* 13th Edition, Pearson, 2012
- Slides having Lucida handwriting font are taken from
  - Physics C1401: Mechanics & Thermodynamics by Frank Sciulli, Columbia University

Reminder

- Mid 1 (Week 6)

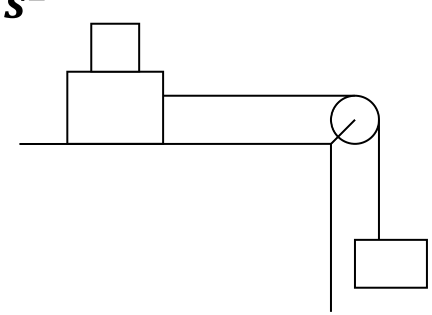
- Topics : Week 1,Week 2, Week 3 , Week 4 & Week 5
- Date / Time : 21st October , 2020 (12.00 Noon till 1 P.M)
- Weightage : 15 Marks

- Assignments/HomeWorks Included

HomeWorks

- A baseball player with mass 79kg, sliding into a base is slowed by a force of friction of 470N. What is the coefficient of kinetic friction between the player and the ground? (Ans , **μ_k= 0.61)**
- The coefficient of static friction between the tires of a car and a dry road is 0.62. The mass of the car is 1500kg.What maximum braking force is obtainable (a) on a level road and (b) on an 8.6º downgrade? (**Ans : (a) F=9123 N (b) F= 9020 N)**
- In fig # 1. "A" is a 4.4kg block and "B" is a 2.6kg block. The coefficient of static and kinetic friction between "A" and the table are 0.18 and 0.15.(a) Determine the minimum mass of the block "C" that must be placed on "A" to keep it from sliding. (b) Block "C" is suddenly lifted off "A" What is the acceleration of block "A".

(Ans : m_c =10 kg , a =2.7m/s^2



Figure#1

HomeWorks

- A worker drags a 150-lb crate across a floor by pulling on a rope inclined 17º above the horizontal. The coefficient of static friction is 0.52 and the coefficient of kinetic friction is 0.35. (a) What tension in the rope is required to start the crate moving? (b) What is the initial acceleration of the crate?

- A 42kg slab rest on a frictionless floor. A 9.7kg block rests on top of the slab as in fig #2 .The coefficient of static friction between the block an the slab is 0.53, while the coefficient of kinetic friction is 0.38.The 9.7kg block is acted on by a horizontal force of 110N. What are the resulting acceleration of (a) the block and (b) the slab?

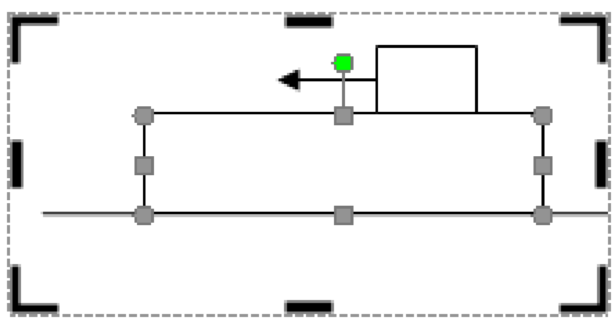


Figure # 2