Motion

Rectilinear Motion:

What is a rectilinear motion?

If a particle is constrained to move along a straight-line path as in fig 1 that motion is called a rectilinear motion.[i]

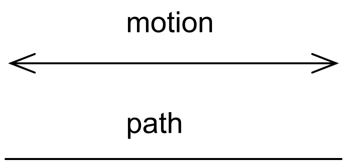


fig 1

Distance and Displacement:[ii]

When we describe how far a place or an object is from our reference point we usually refer to it as distance. But distance is a scalar quantity; it only refers to how far (the magnitude) is it but not the direction it is from our reference.

On the other hand displacement described both the distance from a relative position and the direction of which it heads. Therefore displacement is a vector quantity. The symbol of displacement is *s.*

Example:
Suppose my car is the object of interest and my home is my reference point. CLDH-EI is 3 kms north from my home. What are my distance traveled and my total displacement?

Answer:
Since distance deals only with the length of my travel to and from work, **the answer is 3 kms**. It does not care whether I traveled north or south and east and west but only the total length that I traveled.

Since displacement described only the distance of my end point from the relative position, **the answer is 3 kms north!** If I drive my car back home then my displacement is 0 kms because I'm back at my starting point

Example:
What is the displacement of a shopper in a downtown mall who first walks 100 m straight east and then walks 125 m, west?

Speed and Velocity:

Speed is simply described as the distance traveled over time that the object is moving. On the other hand **velocity** requires both speed and direction.

$$\text{Speed} = \frac{\text{Change in distance}}{\text{Change in time}}$$

$$\text{Ave. Velocity} = \frac{\text{Change in displacement}}{\text{Change in time}}$$

In symbol:

$$v = \frac{\Delta v}{\Delta t}$$

Example:
Referring to the first example, what is the speed and velocity of my car if it takes me 5 min to reach CLDH-EI. Please express in terms of m/s.

Answer:
For Speed:
Since speed is defined as distance over time:

$$\text{Speed} = \frac{\text{Change in distance}}{\text{Change in time}}$$

Convert 3 kms to meters: 3,000 m
Convert 5 min to seconds:
(60s/1 min) * 5 min = 300 s

$$\text{Speed} = \frac{3{,}000 \text{ m} - 0 \text{ m}}{300 \text{ s} - 0 \text{ s}}$$

$$= 10 \text{ m/s}$$

For Velocity:

Since velocity requires speed and direction:

$$\text{Ave. Velocity} = \frac{\text{Change in displacement}}{\text{Change in time}}$$

The displacement is correctly stated as 3000 m, north; and time is still 300 s

$$\text{Ave. Velocity} = \frac{\text{Change in displacement}}{\text{Change in time}}$$

$$v = \frac{3000 \text{ m, north} - 0 \text{ m}}{300 \text{ s} - 0 \text{ s}}$$

$$= 10 \text{ m/s , north}$$

What about my displacement and velocity if I simply drove back and forth?

Example:
On a long distance car trip, a person travels 800 km north (straight line distance on a map) in 12 hr.
(a.) What is the average speed?
(b.) What is the average velocity?

Acceleration:

When the velocity of an object changes with time, we can say that the body has acceleration. The symbol of acceleration is *a*. Average acceleration is defined as:

$$a = \frac{\text{Change in velocity}}{\text{Change in time}}$$

Example:
Calculate the acceleration of a car that changes its velocity from zero to 90 km/hr due west in 15 seconds.

Answer:

Given: v_1 = 0 km/hr
= 0 m/s
v_2 = 90 km/hr
= 25 m/s
t_1 = 0 s
t_2 = 15 s

From the definition of acceleration:

$$a = \frac{\text{Change in velocity}}{\text{Change in time}}$$

The equation will be set up in this:

$$a = \frac{v_2 - v_1}{t_1 - t_2}$$

$$a = \frac{25\text{ m/s} - 0\text{ m/s}}{15\text{ s} - 0\text{ s}}$$

$$= 1.67\text{ m/s}^2$$

Example:
A hospital ambulance rushes to a distress call and reaches the scene of emergency in 15 mins. Immediately after leaving the hospital its velocity reaches from zero to 25 m/s. what is the acceleration of the ambulance.

Graphical representation of vectors:[iii]

A graph, like a picture, is worth a thousand words. Fig 2 is an example of graphical representation of motion.

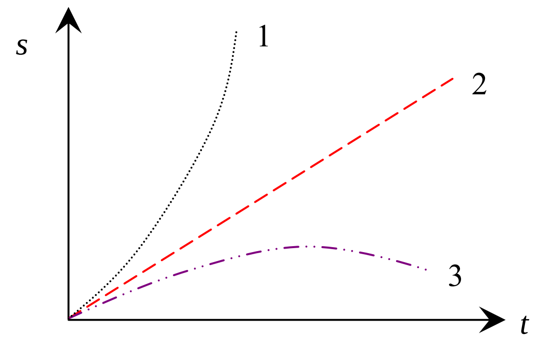


fig2. Graphs of distance versus time for three different motions. The slope of the line is related to the speed of the object being considered.

All three lines on the graph start at the origin, that is s_0 – 0 at t_0 = 0, consistent with our convention that the initial position and initial time are zero. Only line 2 represents a motion where speed is constant; lines 1 and 3 represents motions where speed is changing as time passes.

Exercise 4:
1. A grand prix racer completes a 500 km race in exactly 2 hr and 15 min. What is the average speed of the car in km/hr and m/s?
2. How fast will a motorcycle be going after accelerating from rest for 3.5 s if that motorcycle produces an acceleration of 7.5 m/s^2?
3. A cheetah can reach a final speed of 30 m/s from rest in 6.0 s. Calculate the average acceleration of the cheetah?
4. How long will it take a runner to complete a marathon race of 42.2 km if that runner can maintain an average speed of 4.1 m/s?

Equation of motion:

Before we continue with this topics let us review the symbols used to define the different variables that we have discussed.

Variables	Symbols
Displacement	S
Velocity	V
Time	t
Acceleration	a
“Change in”	Δ

The term “change in” is denoted for the difference between the initial values. Let us look at these equations:

Change in Displacement: $\Delta S = S - S_0$
Change in Time: $\Delta t = t - t_0$
Change in Velocity: $\Delta V = V - V_0$

Derivation of Motion Equations:

Example:
How long will it take the runner to 1500m if he can maintain the speed of 5.4 m/s?

Example:
Now suppose that the sprinter continues to run at 6.0 m/s until the end of the race. After crossing the finish line, the sprinter decelerates at 2.0 m/s^2 How long it will take her to stop?

Example:
A sprinter is able to produce an acceleration of 8.0 m/s^2 for the first 0.75s of a race. Calculate the velocity of the sprinter at the end of the first 0.75s.

Example:
How far does the sprinter in the previous example travel while stopping?

Example:
Starting from rest a powerful dragster can achieve an acceleration of 16 m/s^2 over a distance of 400 m. Calculate the speed of the dragster in kilometer per hour at the end of the 400 m mark?

Gravity and Falling Bodies

If you throw anything upward chances are, it will go down. The reason for this is because the force of gravity. **Gravity** is one of the most familiar forces in nature. It exists, in different magnitude, on all bodies in space.

The reason why, planets orbit around the sun and the moons on the planet is also due to gravity. They balance each other with their own gravitational pull in relation to their distance to each other.

Within the earth, gravity is evident when we see falling bodies. The term **falling bodies** is used for objects under the influence of gravity, weather they are moving upward, downward or sideways.

It is found that if air resistance can be made negligible, falling bodies will accelerate towards the center of the earth at the same rate regardless of its weight. The value of the acceleration of gravity, $g = -9.81\ m/s^2$. The negative sign is indicative of downward movement.

Since the gravitational acceleration is the same for all bodies on earth, we can replace the term *a*, with the term *g*.

Example:
A rock is thrown straight up with an initial speed of 10 m/s. What distance does the rock rise above its point of release? How long does it take the rock to reach its highest point?

Answer:

$V_0 =$ 10 m/s
$V =$ 0 m/s
$S =$?
$t =$?

Distance does the rock rise

$$V^2 = V_0^2 + 2gS$$
$$0 = (10 m/s)^2 + 2(-9.81 m/s^2)S$$
$$S = \frac{(10 m/s)^2}{19.62\ m/s^2}$$
$$= 5.1\ m$$

How long does it take the rock to reach its highest point?

$$V = V_0 + gt$$
$$0 = 10\ m/s + (-9.81\ m/s^2)t$$
$$t = \frac{-10\ m/s}{9.81\ m/s^2}$$
$$= 1.02\ s$$

Example:
A rock is dropped into a 60 m deep well.
(a) Neglecting air resistance, how long will it take the rock to reach the bottom?
(b) Calculate the position of the rock 1.0, 2.0 and 3.0 sec. After its release?

Assignment #3:

1. A soccer player runs 75 m in a straight line down a soccer field in 11 sec. What was her average speed?
2. How far will a car travel from a standing start if it accelerates at 4.0 m/sec^2 for 9.0 s?
3. How long will it take a car to accelerate from 50 to 90 km/hr if it produces an acceleration of 3.0 m/sec^2?
4. If a freight train can accelerate at 0.050 m/sec2, how far must it travel to increase its speed from 2.0 to 8.0 m/s? how long will it take the train to accomplish it?
5. A boulder is ejected straight up out of a volcano at a speed of 80m/s
   (a) To what maximum height will it rise above the point where it was ejected?
   (b) how long will it take to rise and fall back to the point it was ejected?

Exercise 5:

1. What is the final speed of a bicyclist initially moving at 10 m/s who accelerates at a rate of 1.5 m/s^2 for 3 sec.
2. An ice skater decelerates for 5.0 s to a final speed 12 m/s. If the deceleration was at a rate of 1.5 m/sec^2, what was the skater's initial speed?
3. A freight train moving at an initial speed of 40 m/s puts on its brake producing a deceleration of 0.5 m/sec^2
   (a) How long will it take the train to travel the next 100 m?
   (b) At what speed will it be traveling at the end of this 100 m?
4. If you drop an aspirin and it takes 0.18 s to hit the table. How high above the table was the aspirin when it was release?

Projectile Motion[iv]**:**

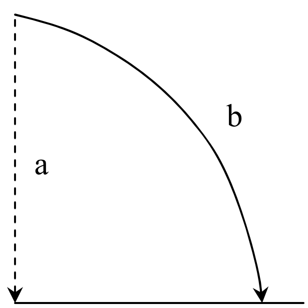
What is a projectile?

A projectile is any body that is given an initial velocity and then follows a path determined entirely by the effect of the gravitational acceleration and air resistance.

The path followed by this particle is called **Trajectory**.

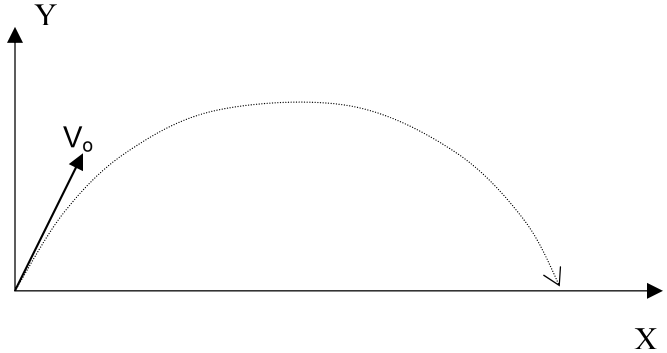
This kind of movement is called "**projectile motion**" and in this case we will ignore air resistance and consider only the effect of gravity ($-9.81\ m/s^2$). Projectile motion is considered a 2 – dimensional motion because it only travels in XY plane. We will not consider the sideway effect of the air on the projectile.

Note: If we neglect air resistance



The time it will take for objects *a* and *b* to fall will be the **SAME!**

To analyze this common type of motion, we'll start with an idealized model, representing the projectile as a single particle with acceleration due to gravity and have constant magnitude and direction.

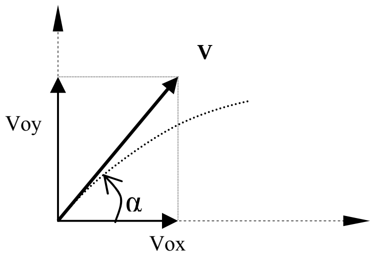


The key to analyzing projectile motion is that we can treat X and Y coordinates separately. The X component of acceleration is Zero, and the Y component of the acceleration is constant and will be set as $-g$ ($-9.81\ m/s^2$). Since X and Y acceleration are constant, we can still use the four equations of motions directly.

For the X motion we can use this equation of motion:

For the Y motion we can substitute y for x, vy for v_x, v_{oy} for v_{ox} and $a_y = -g$

However from the trajectory of the particle we can also say that:



$V_{ox} = V_o \mathrm{Cos}\alpha_o$

$V_{oy} = V_o \mathrm{Sin}\alpha_o$

Using these relations we find:

$x = Xo + (V_o \mathrm{Cos}\alpha_o)t$ Eqn 1

$y = Yo + (V_o \mathrm{Sin}\alpha_o)t - 0.5gt^2$ Eqn 2

$Vx = V_o \mathrm{Cos}\alpha_o$ Eqn 3

$Vy = V_o \mathrm{Sin}\alpha_o - gt$ Eqn 4

We can get a lot of information from these equations. For example, at any time the distance r of the projectile from the origin is given by:

$r = \sqrt{x^2} + \sqrt{y^2}$ Eqn 5

The projectile's speed (the magnitude of its velocity) at any time is

$v = \sqrt{v_x^2} + \sqrt{v_y^2}$ Eqn 6

The direction of the velocity, in terms of the angle α it makes with the x axis is given by:

$\mathrm{Tan}\ \alpha = v_y/v_x$ Eqn 7

The velocity vector **v** is tangent to the trajectory at each point.

We can also derive an equation for the trajectory's shape in terms of x and y and eliminating *t*. From equations 1 and 2:

Example 1:

A motorcycle stunt rides of the edge of the cliff. Just at the edge his velocity is horizontal with magnitude of 9.0 m/s. Find the motorcycle's position, distance from the edge of the cliff and velocity after 5.0 s.

Solution:

Example 2:

Two crickets, Chirpy and Milada, jump from the top of a vertical cliff. Chirpy jumps horizontally and reaches the ground in 3.5 s. Milada jumps with an initial velocity of 95 cm/s and at an angle of 32^0 above the horizontal. How far from the base of the cliff will Milada hit the ground?

Solution:

Example 3:

A batter hits a baseball so that it leaves the bat with an initial speed v_0 = 37.0 m/s at an initial angle α_0 = 53.10. a) find the position of the ball, the magnitude and direction of its velocity when t = 2.0 s. b) find the time when the ball reaches the highest position of its flight and find the height h at this point. c) Find the horizontal range R – that is the horizontal distance from the starting point to the point at which it hits the ground.

Solution:

Example 4:

A stone is thrown with a velocity of 30 m/s pointed 36.87^0 above the horizontal from the top of a cliff 68.4 m high.
(a) how far from the face of the cliff will it strike a horizontal plane through the base of the cliff 68.4 m high.
(b) If sound travels approximately 350 m/s, how long after the stone is thrown will the sound of the impact be heard?

Solution:

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[i] Principles of Engineering Mechanics 2; Yolanda Brondial; 1997
[ii] Physics with health science application; Paul Urone
[iii] Physics with health science application; Paul Urone
[iv] University Physics, Young and Freedman

Force and Newton's Laws of Motion

"Obi-Wan is here. The Force is with him."

- Darth Vader
(Star Wars IV: A New Hope)

What is force?[1]

During our previous discussions, we came upon the words *motion*, *gravity*, *movement*, *acceleration* and *velocity*. But have you ever wondered what caused these things? The answer could then be only FORCE.

Force is simply defined as a *push* or *pull*. If an applied force is the only one acting on a body, then the body will accelerate in the same direction as the force.

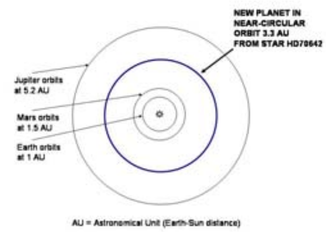
The strength of the force determines the magnitude of the acceleration. If several forces acting on an object the acceleration acted in the same direction as the resultant of these forces.

Forces are very present in our universe. The gravitational forces between bodies in outer space keeps planets in orbit and the also the forces acting between atoms keep everything we see intact.

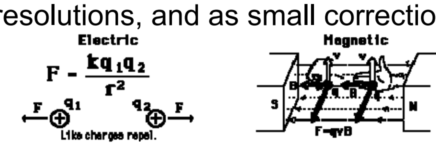
The Fundamental forces of nature[2]

From our understanding there are only four classes of fundamental forces in nature. Although we would just limit our discussions to two, we would still have an overview of what are this forces are about.

The most familiar of these fundamental forces is *gravitational interaction*. If you were wondering why the earth remains at orbit with the sun and why does mangoes fall from trees this is the answer.

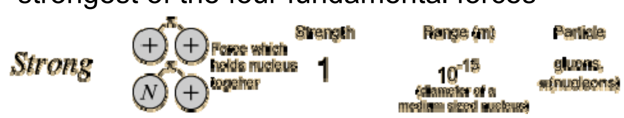


The *electromagnetic force* holds atoms and molecules together. In fact, the forces of electric attraction and repulsion of electric charges are so dominant over the other three fundamental forces that they can be considered to be negligible as determiners of atomic and molecular structure. Even magnetic effects are usually apparent only at high resolutions, and as small corrections.



Strong Force

A force which can hold a nucleus together against the enormous forces of repulsion of the protons is strong indeed. However, it is not an inverse square force like the electromagnetic force and it has a very short range. Yukawa modeled the strong force as an exchange force in which the exchange particles are pions and other heavier particles. The range of a particle exchange force is limited by the uncertainty principle. It is the strongest of the four fundamental forces



The weak interaction involves the exchange of the intermediate vector bosons, the W and the Z. Since the mass of these particles is on the order of 80 GeV, the uncertainty principle dictates a range of about 10^{-18} meters which is about 0.1% of the diameter of a proton.

The weak interaction changes one flavor of quark into another. It is crucial to the structure of the universe in that

1. The sun would not burn without it since the weak interaction causes the transmutation p -> n so that deuterium can form and deuterium fusion can take place.

2. It is necessary for the buildup of heavy nuclei. The role of the weak force in the transmutation of quarks makes it the interaction involved in many decays of nuclear particles which require a change of a quark from one flavor to another. It was in radioactive decay such as beta decay that the existence of the weak interaction was first revealed. The weak interaction is the only process in which a quark can change to another quark, or a lepton to another lepton - the so-called "flavor changes".

The discovery of the W and Z particles in 1983 was hailed as a confirmation of the theories which connect the weak force to the electromagnetic force in electroweak unification.

The weak interaction acts between both quarks and leptons, whereas the strong force does not act between leptons. "Leptons have no color, so they do not participate in the strong interactions; neutrinos have no charge, so they experience no electromagnetic forces; but *all* of them join in the weak interactions."(Griffiths)

Newton's Laws of Motion

To begin with, what is Newton's law all about? Is it about some laws written to make someone famous? The answer is that this law was written to describe the relationship between force and motion. Those relationships were found to apply in every circumstance where an experiment could be performed to test them and came to be known as **Newton's Law of Motion**.

Newton's 1st Law: Inertia

Any body will remain at rest or in motion in a straight line with a constant velocity unless acted upon by an outside force.

The property that causes it to remain at rest or to maintain its constant velocity is called its *inertia* or *mass*. Objects that have heavier mass are more difficult to accelerate that those with lesser mass.

Newton's 2nd Law

The acceleration produced by the forces acting on a body is directly proportional to and in the same direction as the net external force and inversely proportional to the mass of the body.

This law can be written into an equation:

$$a = \frac{Fnet}{m} \qquad \text{eqn 1}$$

Where: *a* = acceleration
Fnet = Net external force
m = mass

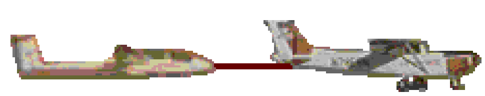
This can now be rewritten into a familiar equation

$$F = ma \qquad \text{eqn 2}$$

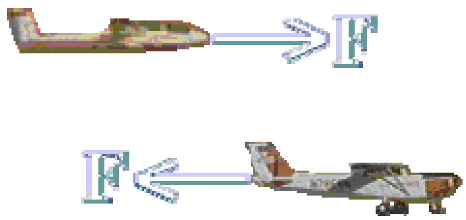
Newton's 3rd Law: Action-Reaction

Whenever one body exerts a force on a second body, the second body exerts a force back on the first that is equal in magnitude and opposite in direction.

This could be the most famous law that Newton ever conceived and this could be the most visible among the Law's of Motion.

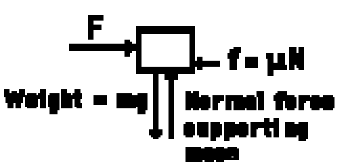


For example let us take the case of a glider being pulled by a plane. The plane exerts a certain amount of force F to pull the glider and obviously the glider is pulled by the same amount of force F.



Free Body Diagram[4]

A free-body diagram is a sketch of an object of interest with all the surrounding objects stripped away and all of the forces acting on the body shown. The drawing of a free-body diagram is an important step in the solving of mechanics problems since it helps to visualize all the forces acting on a single object. The net external force acting on the object must be obtained in order to apply Newton's Second Law to the motion of the object.



A free-body diagram or isolated-body diagram is useful in problems involving <u>equilibrium of forces</u>.

Free-body diagrams are useful for setting up standard mechanics problems

** For self study and appreciation

FBD on BIOMECHANICS

A biomechanical system is a single body or object (or several connected bodies) that can be isolated from all surrounding body segments or objects that it contacts. The isolated system can then be analyzed by determining the forces acting upon it. For example, if the system were a foot segment weight bearing on the ground, it would have gravitational forces, ground reaction forces, body weight (above the foot) and muscle forces acting on it.

The isolation of any system is accomplished by drawing a **free body diagram**, which is a representation of the isolated body segment (or several segments) showing all forces applied to it (not by it) by other bodies that are considered to be removed.

The ability to draw and accurate free body diagram is absolutely essential to understanding the effects of forces that act on and are produced by living bodies. Without this basic understanding you cannot effectively begin to quantify the effects of the external forces.

Drawing the Free Body Diagram

1. Decide which body segment (or segments) is (are) to be isolated from all surrounding bodies. In the example where the foot is the system, you would not draw the ground. Make sure you understand where the separation points are, as these should include locations where forces of interest but of unknown vector are located.

2. Isolate the system by means of a diagram that represents its complete external body. You should not use stick figures, as you cannot accurately draw points of force applications on these. If the system is the foot draw the outline of the whole foot. The diagram of the external boundary should be a closed surface that defines the isolation of the body from all other contacting surfaces.

3. **Note:** In many of my link segment analyses that you will also perform later in the course, you will notice I do use stick figures. This is because these models represent the limb segments as rigid levers joined by hinge joints. They are specifically used to calculate the net force and the net muscle moment at the joint and as such, they are **NOT** free body diagrams. Do not confuse them as such.

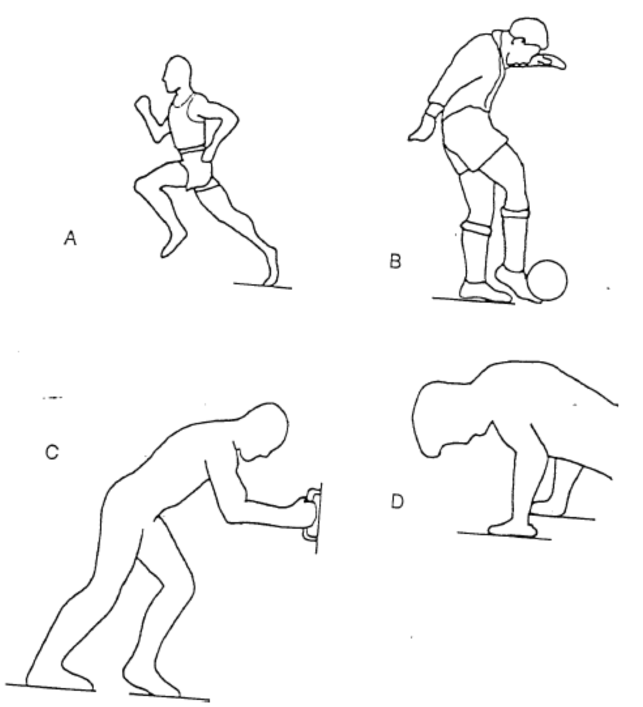
4. Draw vector arrows to show the proper point of **application, magnitude** and **direction** of **all forces** that act on (not by…..be careful) the system. Be sure to include friction and air resistance (if applicable) and the non-contact force of gravity. Your arrows should indicate the approximate magnitude of known forces. Represent unknown forces as best you can (draw them in a positive direction).

This will serve as your assignment

UNMARKED PRACTICE QUESTIONS

Draw free body diagrams of the following:
a) the runners right foot
b) the shank and foot system of the soccer player
c) the forearm of the worker
d) the arm during the push-up

Be sure to include all contact and non-contact forces. Separate out joint reaction force and muscle force.

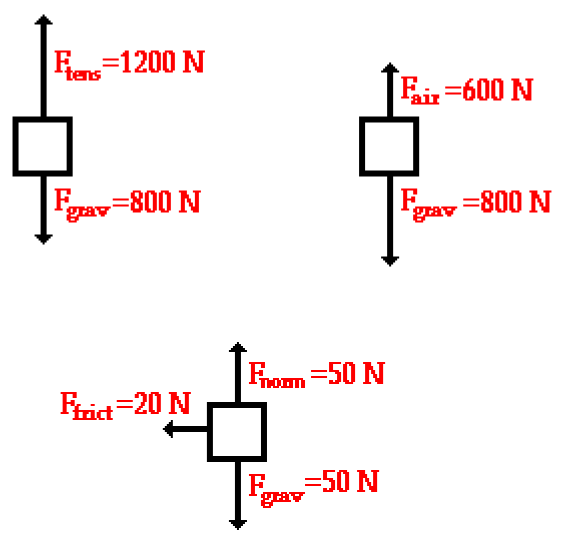


Determining the Net Force[5]

By this time, Newton's first law of motion ought to be thoroughly understood.

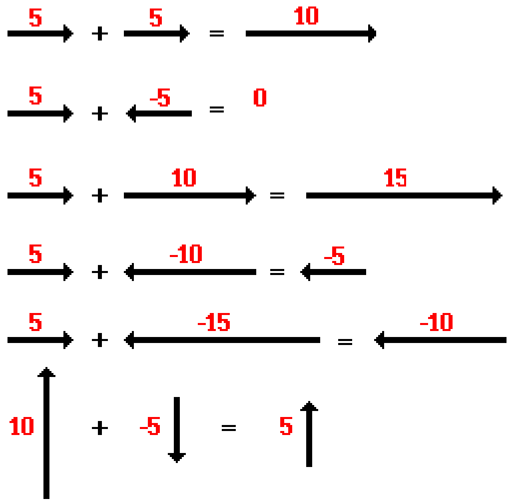
> *An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force.*

In the above statement of Newton's first law, the unbalanced force refers to that force which did not become completely balanced (or canceled) by the other individual forces. An unbalanced force exists whenever all vertical forces (up and down) do not cancel each other and/or all horizontal forces do not cancel each other. The existence of an unbalanced force for a given situation can be quickly realized by looking at the free-body diagram for that situation. Free-body diagrams for three situations are shown below. Note that the actual magnitudes of the individual forces are indicated on the diagram.

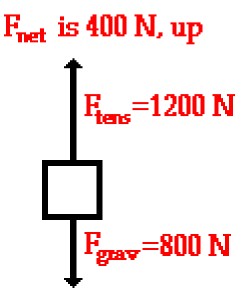


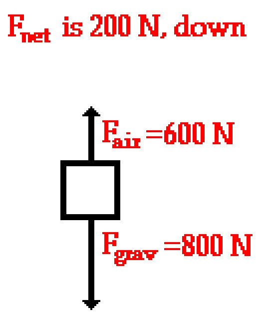
In each of the above situations, there is an unbalanced force. Is commonly said that in each situation there is a *net force* acting upon the object. The net force is the vector sum of all the forces, which act upon an object. That is to say, the net force is the sum of all the forces, taking into account the fact that a force is a vector and two forces of equal magnitude and opposite direction will cancel each other out. At this point, the rules for summing vectors (such as force vectors) will be kept relatively simple.

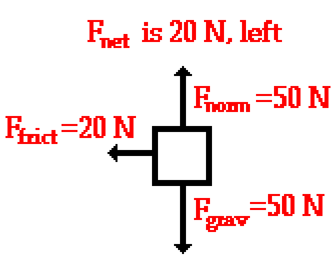
Observe the following summations of two forces:



These rules for summing vectors can be applied to the previously shown free-body diagrams in order to determine the net force (i.e., the vector sum of all the individual forces). The results are shown below.







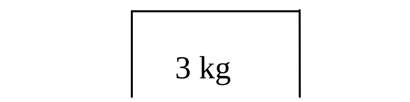
Units of force

Newton's 2nd law of motion as expressed in eqn 2 defines the unit of force. Force is always measured in units of mass times the acceleration, in SI units called Newtons (N)

$$1.0N = 1.0kg - \frac{m}{s^2}$$

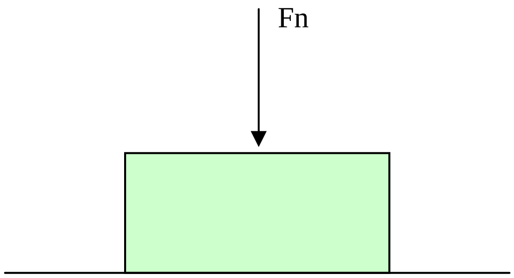
1 Newton is the force required to give a mass of 1 kg an acceleration of 1 $\frac{m}{s^2}$

Ex # 1
A 3kg box was pushed along a frictionless surface. What is the force needed to push it to an acceleration of 1.5 m/s^2

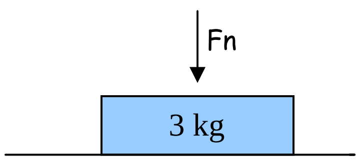


Normal Force[6]

The normal force is the support force exerted upon an object which 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 which are in contact with each other.



Ex # 2
A 3 kg box stands motionless along the surface. What is the normal force acting on the surface?



Friction Force[7]

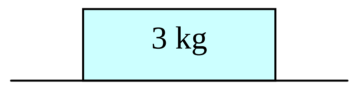
The *friction force* is the force exerted by a surface as an object moves across it or makes an effort to move across it. The friction force opposes the motion of the object. For example, if a book moves across the surface of a desk, then the desk exerts a friction force in the opposite direction of its motion.

Friction results from the two surfaces being pressed together closely, causing intermolecular attractive forces between molecules of different surfaces. As such, friction depends upon the nature of the two surfaces and upon the degree to which they are pressed together. The friction force can be calculated using the equation:

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

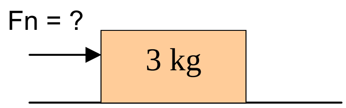
where μ = coefficient of friction

Ex # 3
Let us consider the same box in our previous example. The box remains at rest. What is the frictional force between the surface and the box? The coefficient of friction is $\mu = 0.7$



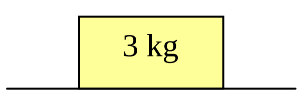
Ex # 4

Determine the amount of force needed to overcome the friction on the box and the floor. M = 0.70



Ex # 5

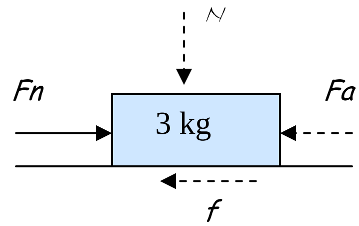
Going back to the previous example, what is the amount of force, Fn, is needed to push the box to an acceleration of 1.5 $\frac{m}{s^2}$? given μ = 1.2



Soln:

This problem is a combination of examples 1 to 5 but the concept is still the same.

To begin our problem we must first draw the free body diagram.



The free body diagram was now drawn for your convenience. Forces that were set in positive direction were set in solid lines and negative forces in broken lines.

Fn is the applied force needed to push the box to an acceleration of $1.5\frac{m}{s^2}$, this is what we are looking for. N is the normal force exerted on the floor by the box. frictional force is denoted by f and always in the opposite direction of the applied force. Fa is the force required to push it to and acceleration of 1.5 m/s^2.

By this time you may already ask why did I set Fa to negative since it should be along Fn? The answer lies in the fact that Fn includes the effect of Fa and for us to determine the true amount of Fn, we should also take into account the force due to acceleration.

Therefore this equation can be set.

$$\sum F_x = 0$$

$$\sum F_x = F_n - F_a - f = 0$$

Where: Fn = net applied force

Fa = ma = 3kg * 1.5 m/s_2

f = μN = .7*(mg)

= 0.7*(3kg * 9.81 m/s_2)

$$F_n - F_a - f = 0$$

$$F_n - 4.5N - 20.6 = 0$$

$$F_n = 25.1N$$

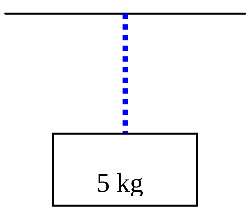
Tensile/Compression Forces

Tensile and compressive forces are very present in our environment. Basically these are not separate concepts to be studied but rather this already the basic applications

The difference between tensile and compression forces is that the former "pulls" and the latter "push". Our discussions will be limited to tensile forces although an example for compressive forces will be presented.

Ex # 6

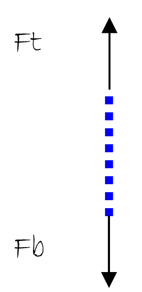
A 5 kg box was hung before delivering it somewhere else. What is the tensile force acting on the rope? Neglect the weight of the rope.



Soln:

To solve this problem, we must first set the free body diagram. In this case let us consider the rope.

The free body diagram is set in this manner. The force exerted by the box is naturally on the downward so in order to balance the force the tensile force Ft is naturally on the upward direction.

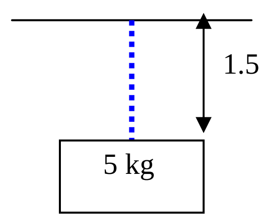


From the free body diagram, the summation of forces can be set

The preceding example has shown to us that the tensile force is simply equal to the force exerted by the box. Now let us try to consider the weight of the rope.

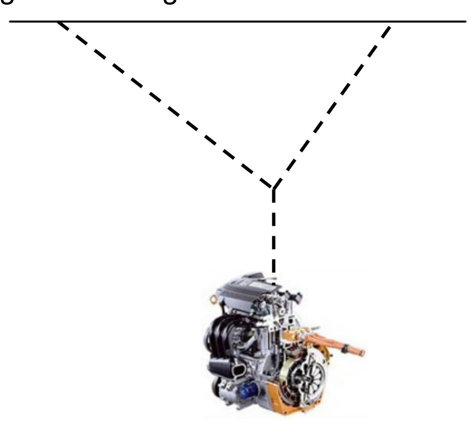
Ex # 7

Let us consider previous problem. Only this time the weight of the box is to be considered. The rope used to hold the box is 1.5 meters long and the box still weighs 5kg. The weight of the rope is 0.75kg per linear meter.



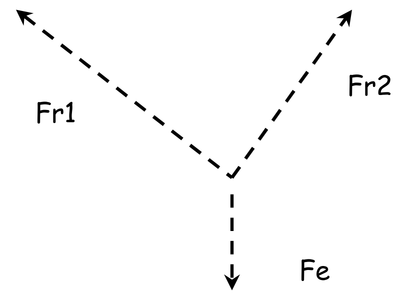
Ex # 8

A 750kg engine was hoisted up from a car. It was hung by two chain ropes as shown. What are the tensile forces exerted on these ropes. Neglect the weight of the chains.



Soln:

The first thing to do is to draw the free body diagram before you set up the equations.



From the free body diagram we can see that the summation of forces will assume this form.

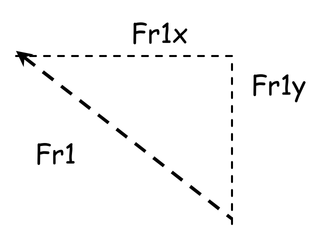
$$\sum F_y = 0$$
$$\sum F_y = Sin45^0 F_{r1} + Sin60^0 F_{r2} - F_e = 0$$

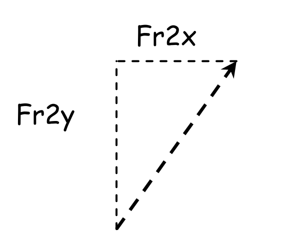
Solving for each variables:

Fe = ma
= 750kg(9.81m/s^2)
= 7357.5N or 7.35kN

But we can also notice that we cannot solve F_{r1} and F_{r2} because we cannot arithmetically two unknown values.

However:





We can now conclude from the Y components of forces that Fr2y and Fr1y are equal.

Hence:

Fr2y = Fr1y

We can reset our equation in this form in terms of Fr2y

$$\sum F_y = F_e - F_{r2y} - F_{r1y} = 0$$
$$\sum F_y = 7.35kN - 2F_{r2y} = 0$$

$$7.35kN = 2F_{r2y}$$
$$F_{r2y} = \frac{7.35kN}{2}$$
$$F_{r2y} = 3.675kN$$

Since

Fr2y = 3.675kN = Sin60^{0}Fr2

Fr2 = 4.24kN

Fr2y = Fr1y

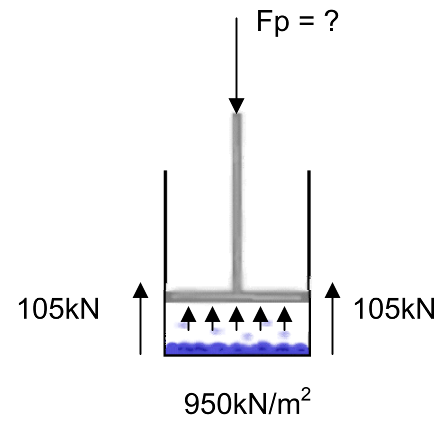
3.675kN = Sin45^{0}Fr1

Fr1 = 5.19kN

**Compressive

Ex # 9

A piston is required to exert a certain amount of force to compress fluid inside the cylinder. The area of the cylinder is 0.05m^2. The fluid exerts a force of 950kN/m^2 on the cylinder. The cylinder also exerts friction force at the side of the piston *f* = 105 kN.



[1] Physics with health science applications, P Peter Urone
[2] http://hyperphysics.phyastr.gsu.edu/hbase/forces/funfor.html#c3
[3] http://www.physics.isu.edu/~keeter/phys211dir/quiz5/md3th1c.htm
[4] http://hyperphysics.phy-astr.gsu.edu/hbase/freeb.html
[5] http://www.glenbrook.k12.il.us/gbssci/phys/Class/newtlaws/u2l2d.html
[6] http://www.glenbrook.k12.il.us/gbssci/phys/Class/newtlaws/u2l2b.html
[7] http://www.glenbrook.k12.il.us/gbssci/phys/Class/newtlaws/u2l2b.html