Forces

System vs Environment:

system - *the object the force is applied to*

environment - *the world around the object that exerts the force*

Type Forces:

Contact - *is applied by touching*

Long-range - *exerted without contact*

magnetic
electromagnetic
gravitational
nuclear

Nov 6-7:57 AM

Four naturally occuring forces

gravitational

electromagnetic

weak nuclear

strong nuclear

Nov 6-8:23 AM

Forces have agents (identifiable causes)

"no agent, no force"

magnetic - spinning electrons and domains

electric - moving electrons

gravitational - mass

Nov 6-8:04 AM

TABLE 6–2

Some Types of Forces

Force	Symbol	Definition	Direction
Friction	F_f	The contact force that acts to oppose sliding motion between surfaces	Parallel to the surface and opposite the direction of sliding
Normal	F_N	The contact force exerted by a surface on an object	Perpendicular to and away from the surface
Spring	F_{sp}	A restoring force, that is, the push or pull a spring exerts on an object	Opposite the displacement of the object at the end of the spring
Tension	F_T	The pull exerted by a string, rope, or cable when attached to a body and pulled taut	Away from the object and parallel to the string, rope, or cable at the point of attachment
Thrust	F_{thrust}	A general term for the forces that move objects such as rockets, planes, cars, and people	In the same direction as the acceleration of the object barring any resistive forces
Weight	F_g *or,* F_w	A long-range force due to gravitational attraction between two objects, generally Earth and an object	Straight down toward the center of Earth

6.1 Force and Motion **123**

Nov 15-7:51 AM

Common misconceptions about forces The world is dominated by friction, and so Newton's ideal, friction-free world is not easy to visualize. In addition, many terms used in physics have everyday meanings that are different from those understood in physics. Here are some examples of common, but mistaken ideas about forces.

- **When a ball has been thrown, the force of the hand that threw it remains on it.** No, the force of the hand is a contact force; therefore, once contact is broken, the force is no longer exerted.
- **A force is needed to keep an object moving.** If there is no net force, then the object keeps moving with unchanged velocity. If friction is a factor, then there is a net force and the object's velocity will change.
- **Inertia is a force.** Inertia is the tendency of an object to resist changing its velocity. Forces are exerted on objects by the environment; they are not properties of objects.
- **Air does not exert a force.** Air exerts a huge force, but because it is balanced on all sides, it usually exerts no net force unless an object is moving. You can experience this force only if you remove the air from one side. For example, when you stick a suction cup on a wall or table, you remove air from one side. The suction cup is difficult to remove because of the large unbalanced force of the air on the other side.
- **The quantity *ma* is a force.** The equals sign in $F = ma$ does not define *ma* as a force. Rather, the equal sign means that experiments have shown that the two sides of the equation are equal.

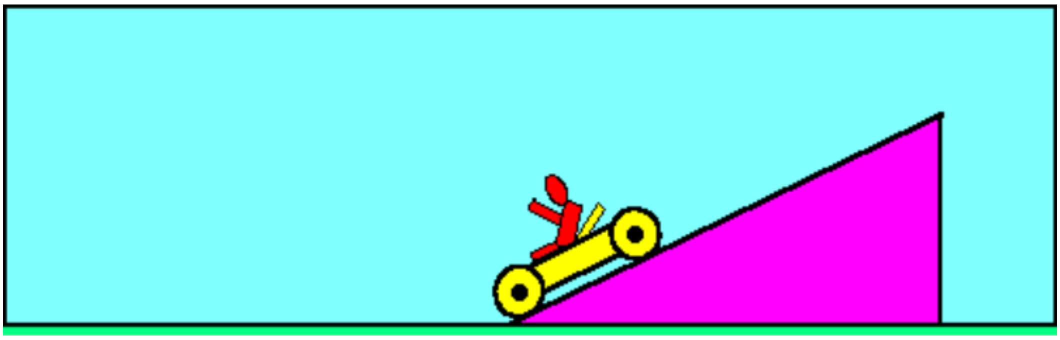
Nov 15-7:51 AM

1^{st} Law	2^{nd} Law	3
inertia *resistance to a change in motion*	$a = \Sigma F/m$	action/reaction
measured in MASS (kg) pan balance	$\Sigma F = ma$ measured in Newtons spring scale	*whenever a force is applied an equal and opposite force is applied in response*
$\Sigma F = 0$	$\Sigma F > 0$	Forces act in pairs
balanced forces *object in equilibrium*	unbalanced forces	Forces are equal and opposite
rest or Vel_c	acceleration *in direction of net force*	if body A acts on body B, then, body B acts on body A

Nov 15-7:17 AM

First Law - Inertia

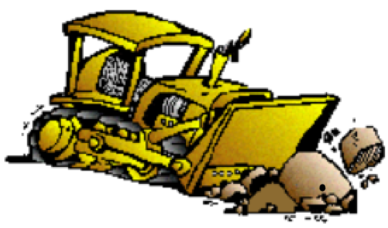
Newton`s first law of motion is the law of **inertia**. *This law states that every object remains in a state of rest or uniform motion in a straight line unless acted upon by outside (unbalanced) forces*. Inertia is a **property** of both moving and resting objects. Moving objects tend to stay in motion and resting objects tend to stay still. These tendencies are defined as inertia. It takes a force to cause a resting object to move, and it takes a force to stop a moving object. Inertia is the resistance to change. Once an object is set in motion it will continue to move until some other force is applied to make it stop. If an astronaut were to kick a ball while in deep space the ball would continue to go in a straight line. But if the ball was kicked on earth, the ball would be acted upon by the forces of air friction and gravity. It would eventually come back to the ground and stop. Another example of inertia is a person in a moving car. If the car is moving forward and the brakes are suddenly applied, the car will slow down and stop but the person will tend to continue to go forward. It tries to keep moving as before. Seat belts are worn to keep a person from hitting the windshield



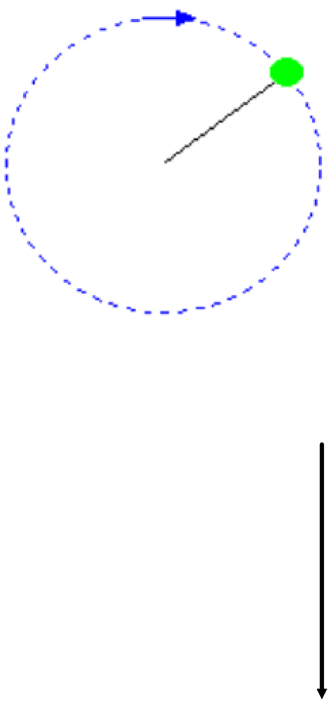
Nov 6-8:16 AM

The hammer is massive and is moving and wants to stay moving!

The rock is at rest and wants to stay at rest!

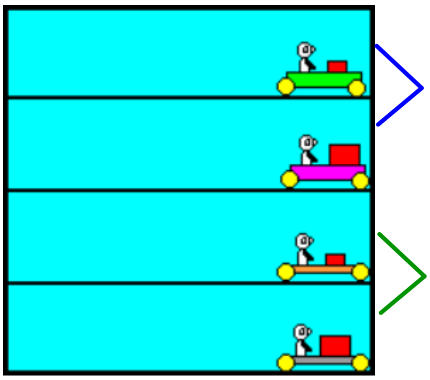


Nov 6-8:18 AM



The ball doesn't want to go in a circular path, so when the string breaks it goes in a straight line at a constant speed!

Nov 6-8:20 AM



<u>Second Law - Acceleration</u>

$\Sigma F = ma$

Newton`s second law of motion *states that if a force acts on an object, the object will move in the direction of that force.* If the force is continually applied, the object will continually gain speed. This constant increase in speed is call **acceleration**. The stronger the force, the faster the object will accelerate. Consider two race cars that are identical except that one has a large engine and the other has a small engine. If these two cars were to race, which would accelerater faster and win the race? The one with the larger engine would win because it applies a greater force to the wheels.

Also massive objects are harder to accelerate than lighter objects. What if a very light car with a large engine was to enter? Would it win or lose the race? How would a light car with a smaller engine perform? Observe the above animation as observe the results of such a race.

Feb 22-12:42 PM

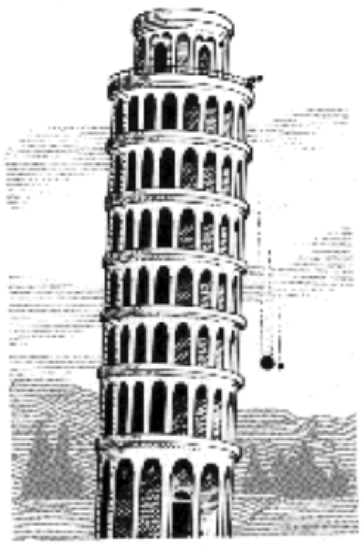
6.2 Using Newton's Laws

Aristotle: heavier object will fall faster

Galileo: all objects fall at the same rate

$\Sigma F = ma$

$a = \frac{\Sigma F}{m}$



acceleration varies *directly* with net force and *inversely* with mass

- acceleration is always in the direction of the net force

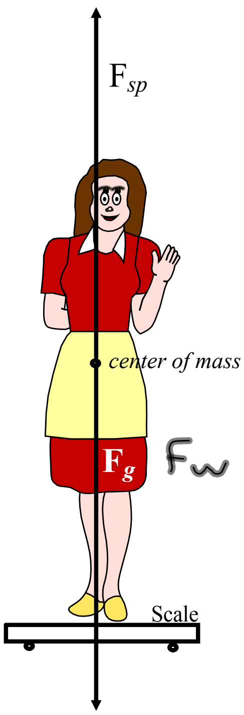
rest

$a = 0$

$\Sigma F = 0$

$F_{sp} + F_g = 0$

$F_{sp} = -F_g$



if $F_g = -450$ N,
then $F_{sp} = +450$ N

F_g or F_w

weight = pull of gravity

mr G.

92 kg

$F_w = mg$

$F_w = 92\,kg(-9.8\ m/s^2)$

$F_w = -90\bar{0}\ N$

Nov 12-1:11 PM

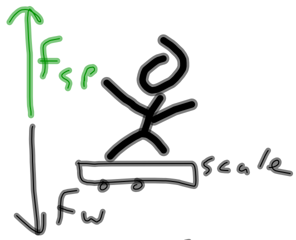
I have a mass of 92 kg. What does the spring scale read if I'm at rest? What happens if I'm standing on a spring scale in an elevator that accelerates upward at 3.0 m/s^2 for 3.0 s?

m = 92 kg

1) Type motion? rest

2) ∴ Type force? $\Sigma F = 0$

3) draw force diagram



F_w = force of gravity on an object

$F_w = mg$ (g = accel. due to gravity, $-9.8\ m/s^2$)

$\Sigma F = 0$

$F_{sp} + F_w = 0$

$F_{sp} = -F_w$

$F_{sp} = -mg$

$F_{sp} = -(92\,kg)(-9.8\ m/s^2)$

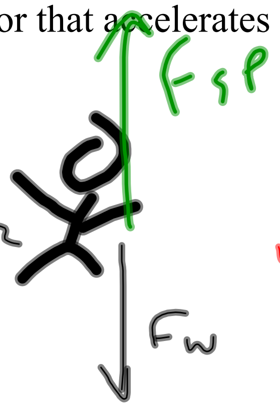
$F_{sp} = 90\bar{0}\ kg\,m/s^2$

$+90\bar{0}\ N$

Nov 12-10:30 AM

I have a mass of 92 kg. What does the spring scale read if I'm at rest? What happens if I'm standing on a spring scale in an elevator that accelerates upward at 3.0 m/s^2 for 3.0 s?

$m = 92\,kg$
$a = +3.0\,m/s^2$
$t = 3.0\,s$
$F_{sp} = ?$



1) Type motion? accel
2) ∴ Type force
2 nd
$\Sigma F > 0$
$\Sigma F = ma$

accel.
∴ $\Sigma F > 0$
$\Sigma F = ma$

$F_{sp} + f_W = ma$

$F_{sp} = ma - F_w$

$F_{sp} = ma - mg$

$F_{sp} = m(a-g)$

$F_{sp} = 92.0\ kg\ [3.0\ m/s^2 - (-9.8\ m/s^2$

$F_{sp} = 92.0\ kg\ (12.8\ m/s^2)$

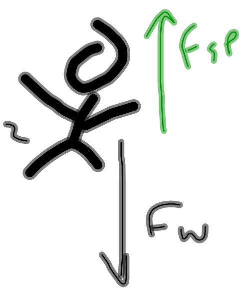
$F_{sp} = 1180\ kg\ m/s^2 \quad = \quad 1180\ N$

Nov 12-11:11 AM

I have a mass of 92 kg. What does the spring scale read if I'm at rest? What happens if I'm standing on a spring scale in an elevator that accelerates ~~upward~~ down at 3.0 m/s^2 for 3.0 s?

↳ $-3.0\,m/s^2$
∴ $\Sigma F \downarrow$
" $-$ "

$m = 92\,kg$
$a = +3.0\,m/s^2$
$t = 3.0\,s$
$F_{sp} = ?$



1) Type motion? accel
2) ∴ Type force
$\Sigma F > 0$
$\Sigma F = ma$

accel.
∴ $\Sigma F > 0$
$\Sigma F = ma$

$F_{sp} + f_W = ma$

$F_{sp} = ma - F_w$

$F_{sp} = ma - mg$

$F_{sp} = m(a-g)$

$F_{sp} = 92.0\ kg\ [3.0\ m/s^2 - (-9.8\ m/$ (handwritten above 3.0: -3.0)

$F_{sp} = 92.0\ kg\ (12.8\ m/s^2)$ (12.8 crossed out, handwritten: $+6.8\ m/s^2$)

$F_{sp} = 1180\ kg\ m/s^2 \quad = \quad 1180\ N$ (crossed out)

F_{sp} $+630\,N$

Nov 13-11:05 AM

Friction:

1) caused by the interaction of 2 + objects

2) opposite (opposes) motion

3) Types- Kinetic, static, sliding, rolling

4) size:
   nature of surfaces
   force pushing surfaces together

Nov 13-8:22 AM

frictional characteristic of the surfaces
"coefficient of friction"

$$F_f = \mu F_N$$

force of friction

Normal Force
force pushing surfaces together
⊥ to surface

Nov 14-7:49 AM

"μ" is the "coefficient of friction" and is the frictional property of the two surfaces in contact. Each pair of surfaces has its own unique value of μ. Note that μ is a ratio of forces, and therefore a pure number.

$$\mu = F_f / F_N$$

Nov 14-7:50 AM

You pull a 25.0 kg box across a floor at a consant velocity with a horizontal force of 125 N. What is μ?

Nov 14-8:12 AM

You pull a 25.0 kg box across a floor at a consant velocity with a horizontal force of 125 N. What is μ?

1) data?

Nov 14-8:08 AM

You pull a 25.0 kg box across a floor at a consant velocity with a horizontal force of 125 N. What is μ?

m_{box} = 25 kg
f_h = 125 N
v_c
μ?

2) Type motion?

3) Type force?

Nov 14-8:08 AM

You pull a 25.0 kg box across a floor at a consant velocity with a horizontal force of 125 N. What is μ?

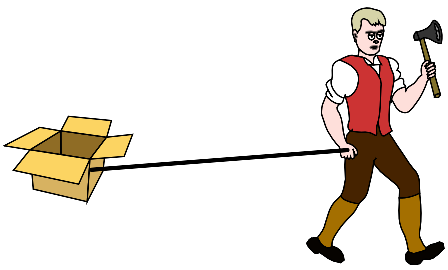
m_{box} = 25 kg
f_h = 125 N
v_c
μ?

horizontal (x)	vertical (y)
v_c ∴ 1st Law	rest
ΣF = 0	ΣF = 0

4) picture?   (diagram)

Nov 14-8:08 AM

You pull a 25.0 kg box across a floor at a consant velocity with a horizontal force of 125 N. What is μ?



m_{box} = 25 kg
f_h = 125 N
v_c
μ?

horizontal (x)	vertical (y)
v_c ∴ 1st Law	rest
ΣF = 0	ΣF = 0

5) force diagram

Nov 14-8:09 AM

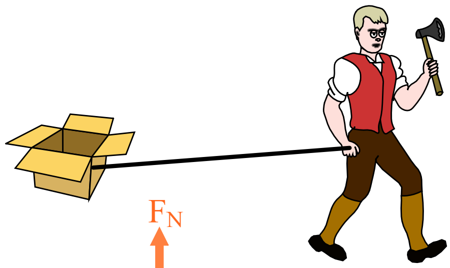
You pull a 25.0 kg box across a floor at a consant velocity with a horizontal force of 125 N. What is μ?

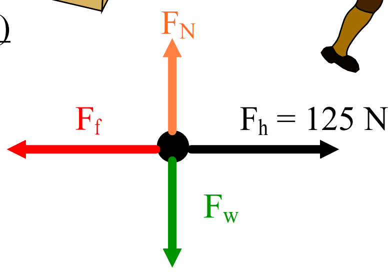
$m_{box} = 25$ kg
$f_h = 125$ N
v_c
μ?

<u>horizontal (x)</u> <u>vertical (y)</u>

v_c ∴ 1st Law — rest

$\Sigma F = 0$ — $\Sigma F = 0$





6) Determine any forces you don't

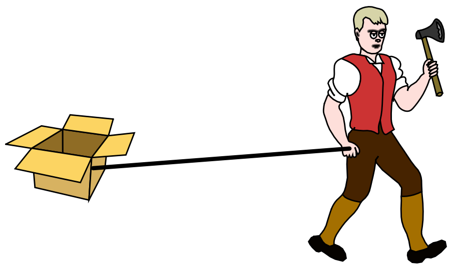
You pull a 25.0 kg box across a floor at a consant velocity with a horizontal force of 125 N. What is μ?

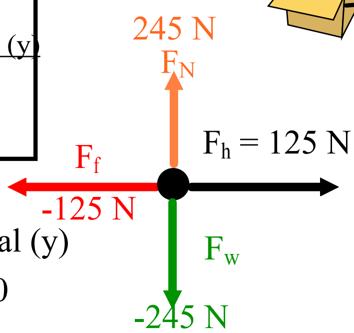
$m_{box} = 25$ kg
$f_h = 125$ N
v_c
μ?

<u>horizontal (x)</u> <u>vertical (y)</u>

v_c ∴ 1st Law — rest

$\Sigma F = 0$ — $\Sigma F = 0$





$F_w = mg$

$F_w = 25 \text{ kg } (-9.8 \text{ m/s}^2)$

$F_w = -245$ N

horizontal (x)

$\Sigma F = 0$

$F_f + F_h = 0$

$F_f = -F_h$

$F_f = -(125 \text{ N})$

$F_f = -125$ N

vertical (y)

$\Sigma F = 0$

$F_w + F_N = 0$

$F_N = -F_w$

$F_N = -(mg)$
$F_N = -(-245 \text{ N})$
$F_N = (245 \text{ N})$

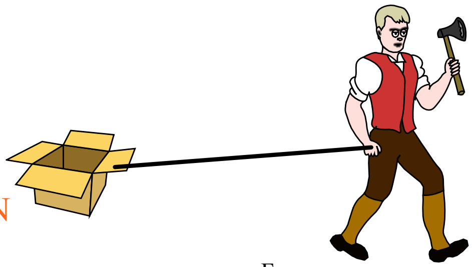
7) Find unknown

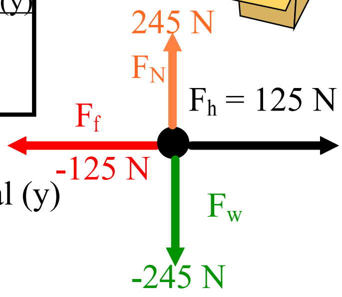
You pull a 25.0 kg box across a floor at a consant velocity with a horizontal force of 125 N. What is μ?

$m_{box} = 25$ kg
$f_h = 125$ N
v_c
μ?

horizontal (x): v_c ∴ 1st Law, $\Sigma F = 0$

vertical (y): rest, $\Sigma F = 0$





$F_w = mg$

$F_w = 25\text{ kg }(-9.8\text{ m/s}^2)$

$F_w = -245$ N

horizontal (x)

$\Sigma F = 0$

$F_f + F_h = 0$

$F_f = -F_h$

$F_f = -(125\text{ N})$

$F_f = -125$ N

vertical (y)

$\Sigma F = 0$

$F_w + F_N = 0$

$F_N = -F_w$

$F_N = -(mg)$
$F_N = -(-245\text{ N})$
$F_N = (245\text{ N})$

$\mu = F_f/F_N$

$\mu = -125\text{ N}/-245\text{ N}$

$\mu = 0.510$

Nov 14-7:55 AM

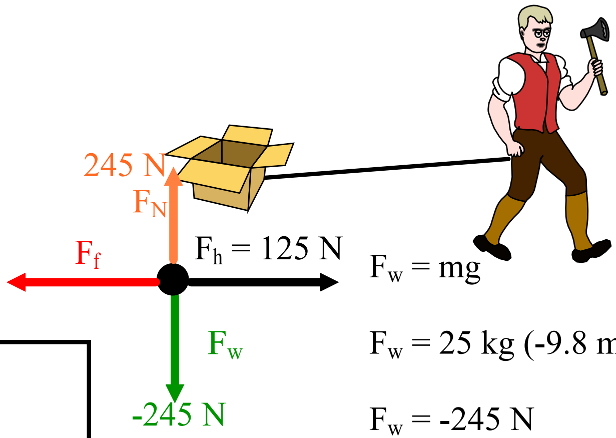
You pull a 25.0 kg box across a waxed floor with an acceleration of 2.50 m/s^2 with a horizontal force of 125 N. What is μ?

Nov 14-8:24 AM

You pull a 25.0 kg box across a waxed floor with an acceleration of 2.50 m/s^2 with a horizontal force of 125 N. What is μ?

$m_{box} = 25$ kg
$f_h = 125$ N
$a = 2.50\ m/s^2$
μ?

<u>horizontal</u>	<u>vertical</u>
a ∴ 2^{nd} Law	rest
$\Sigma F = ma$	$\Sigma F = 0$



$F_w = mg$

$F_w = 25\ kg\ (-9.8\ m/s^2)$

$F_w = -245$ N

$F_f + F_h = ma$

$F_f = ma - F_h$

$F_f = 25.0\ kg(2.50\ m/s^2) - (125\ N)$

$F_f = 62.5\ N - (125\ N)$

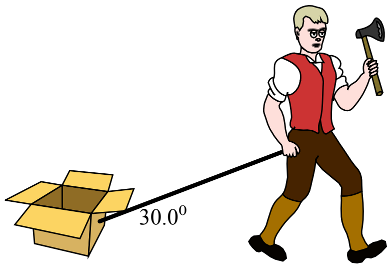
$F_f = -62.5$ N

$\mu = F_f/F_N$

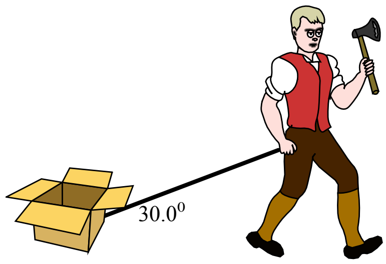
$\mu = -62.5\ N/-245\ N$

$\mu = 0.255$

You pull a 25.0 kg box across a floor at a consant velocity with a force of 125 N directed 30.0^0 above the horizontal. What is μ?

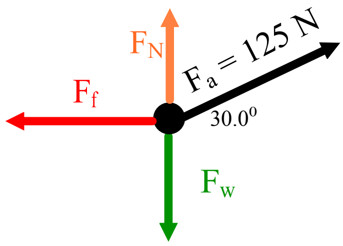


You pull a 25.0 kg box across a floor at a consant velocity with a force of 125 N directed 30.0^0 above the horizontal. What is μ?



$m_{box} = 25$ kg
$f_a = 125$ N at 30.0^0
v_c
μ?

horizontal	vertical
$v_c \therefore$ 1st Law	rest
$\Sigma F = 0$	$\Sigma F = 0$



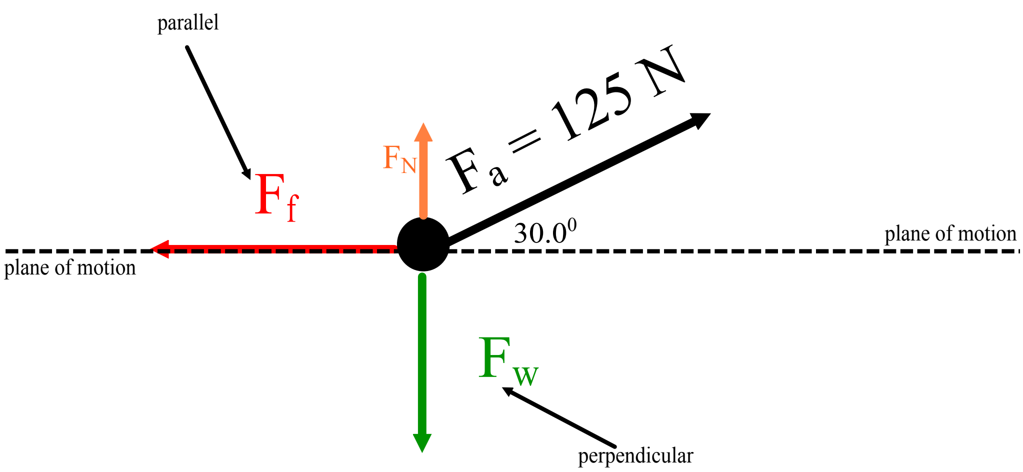
parallel to motion

$\mu = F_f/F_N$

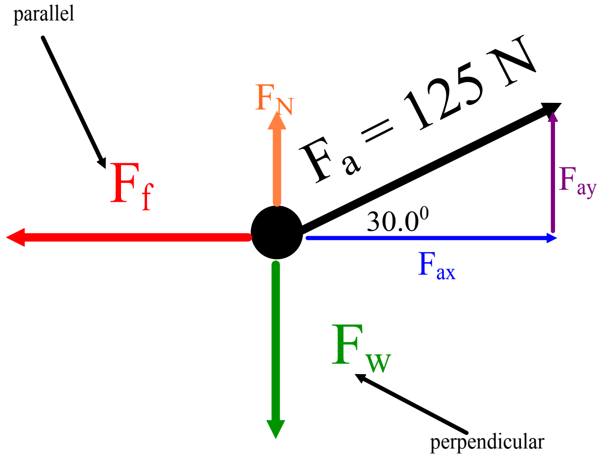
perpendicular to motion

break down (resolve) all forces into their parallel and perpendicular components!!!!!

Nov 14-10:06 AM



Nov 14-10:14 AM



F_{ay} = sin. 30^0 (125 N) = + 62.5 N

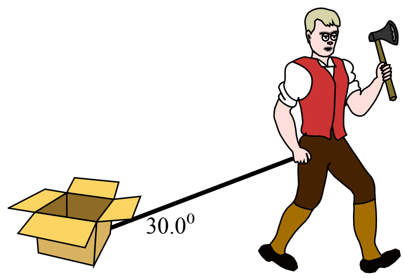
F_{ax} = cos. 30^0 (125 N) = +108 N

Now that you've broken the angled 125 N force into its "x" and "y" (horizontal and vertical) components you don't use it (the 125 N force), you just use its components!!!

Nov 14-10:16 AM

You pull a 25.0 kg box across a floor at a consant velocity with a force of 125 N directed 30.0^0 above the horizontal. What is μ?

$m_{box} = 25$ kg
f_a= 125 N at 30.0^0
v_c
μ?

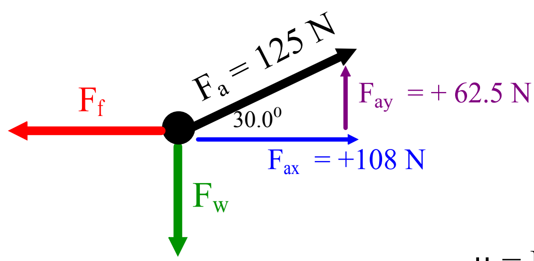


<u>horizontal</u>	<u>vertical</u>
v_c ∴ 1^{st} Law	rest
$\Sigma F = 0$	$\Sigma F = 0$

$F_w = mg$

$F_w = 25\text{ kg }(-9.8\text{ m/s}^2)$

$F_w = -245$ N



$\mu = F_f/F_N$

Nov 14-10:06 AM