Do statics after N1

First do $\vec{F}_{net} = 0$
Also static friction
Roping and pulleys
} in N1

Then (N5) is all about torque.

$$\vec{p} = m\vec{v}$$

$$\frac{d\vec{p}}{dt} = \vec{F}_{net} = \sum_A \vec{F}_A$$

Statics: systems at rest

$$\vec{v} = 0 \Rightarrow \frac{d\vec{p}}{dt} = 0 \Rightarrow \vec{F}_{net} = 0$$

Net force on a static object is zero.

N3T.2 A crate sits on the ground. You push as hard as you can on it, but you cannot move it. At any given time when you are pushing, what is the magnitude of the static friction force exerted on the crate by its contact interaction with the ground compared to the magnitude of your push F_p?

N1-2

A. $F_{SF} < F_p$
B. $F_{SF} = F_p$
C. $F_{SF} > F_p$
D. $F_{SF} = 0$!
E. We do not have enough information to answer.

Static friction is an adjustable (or reactive) force.
Its magnitude increases to counteract other forces in order to prevent relative motion between two surfaces, up to a certain limit

$$0 \le F_{SF} \le F_{SF,\,max}$$

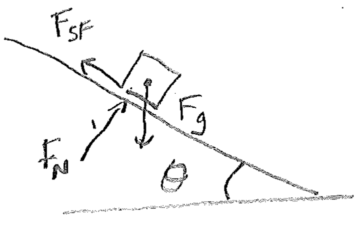
The limit is

$$F_{SF,\,max} = \mu_s F_N$$

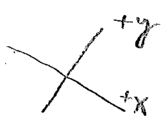
μ_s = coeff. of static friction of the surface
$(0 \le \mu_s \lesssim 1)$
F_N = normal force at the surface where friction is acting.

N3T.3 A box sits at rest on an inclined plank. How do the magnitudes of the normal force and the gravitational force exerted on the box compare? (*Hint:* Draw a picture!)

A. $F_N < F_g$
B. $F_N = F_g$
C. $F_N > F_g$
D. $F_N = 0!$
E. We do not have enough information to answer.

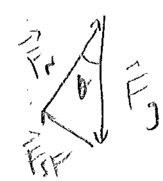


use rotated coordinate system



$$0 = \vec{F}_{net} = \begin{pmatrix} F_{net,x} \\ F_{net,y} \end{pmatrix} = \begin{pmatrix} -F_{SF} + F_g \sin\theta \\ F_N - F_g \cos\theta \end{pmatrix} \Rightarrow \begin{array}{l} F_N = F_g \cos\theta \\ F_{SF} = F_g \sin\theta \end{array}$$

Net force diagram



max. angle at which box won't slide?

$$F_{SF} \leq F_{SF,max} = \mu_s F_N$$

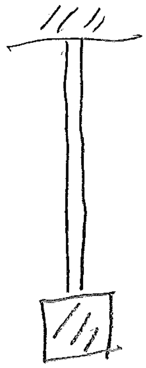
$$mg \sin\theta \leq \mu_s mg \cos\theta$$

$$\frac{\sin\theta}{\cos\theta} \leq \mu_s$$

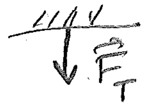
$$\tan\theta \leq \mu_s$$

[Demo: board and book]

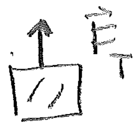
Ideal "massless" string

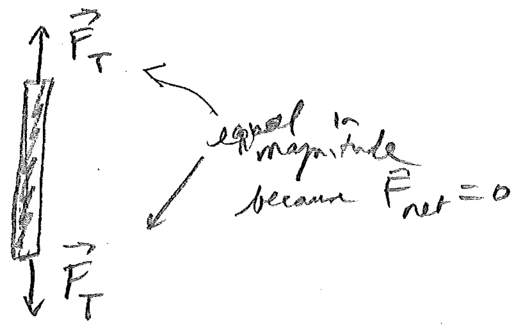


The <u>tension</u> in a string is the magnitude of the force it exerts on an object to which it is attached



and therefore of the force that the object exerts on it (Newton 3rd)





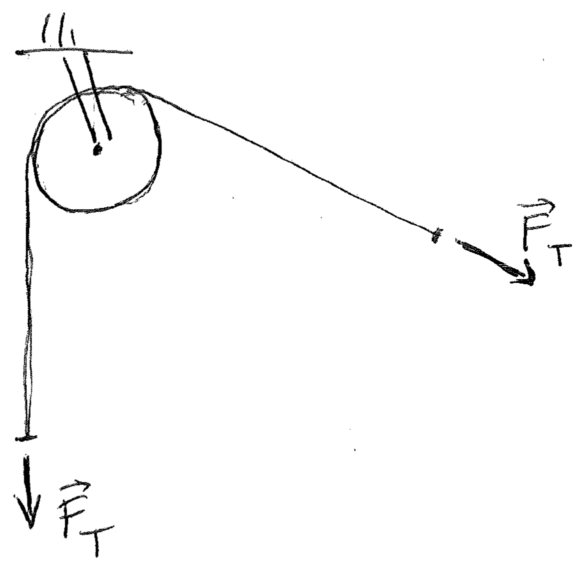
Tension is constant along an ideal massless string because $\vec{F}_{net} = 0$.

(Tension will increase as you go up a physical string due to its weight.)

Tension is always positive because "you can't push a string."

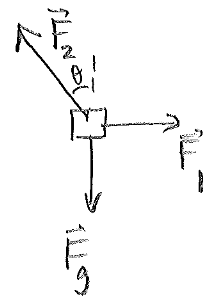
Pulley

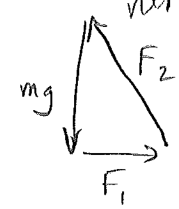
an ideal pulley redirects the force of tension but does not change its magnitude



N1-6

[N5.T1]c
must get it



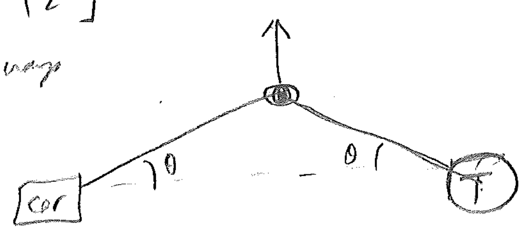


$\Rightarrow F_2 > mg$

$$F_{net} = \begin{pmatrix} 0 \\ 0 \end{pmatrix} = \begin{pmatrix} F_1 \\ 0 \end{pmatrix} + \begin{pmatrix} 0 \\ -mg \end{pmatrix} + \begin{pmatrix} -F_2 \sin\theta \\ F_2 \cos\theta \end{pmatrix}$$

$$\Rightarrow F_2 = \frac{mg}{\cos\theta}, \quad F_1 = F_2 \sin\theta = mg \tan\theta$$

[N5.T2]c
2010 split 3 ways

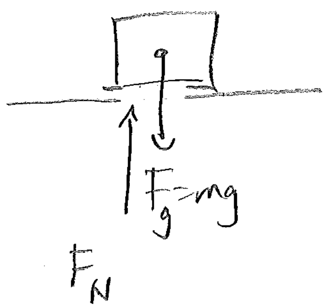


FBD for chain link

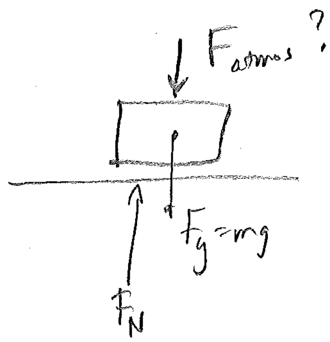
$$F_{net} = \begin{pmatrix} 0 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ F_p \end{pmatrix} + \begin{pmatrix} -T\cos\theta \\ -T\sin\theta \end{pmatrix} + \begin{pmatrix} T\cos\theta \\ -T\sin\theta \end{pmatrix}$$

$$\Rightarrow F_p = 2T\sin\theta \Rightarrow T = \frac{F_p}{2\sin\theta}$$

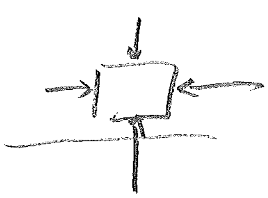
Optional: buoyancy



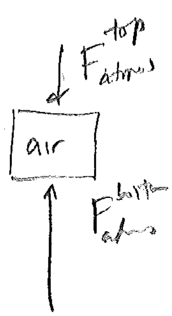
$$F_N = F_{grav} = mg$$



Does atmospheric pressure increase normal force?

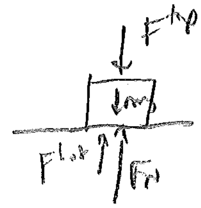


Balanced on all sides
(unless suction cup on bottom)



Not quite balanced! $F_{atmos} \downarrow$ as $z \uparrow$

$$\underbrace{F^{top} - F^{bottom}}_{F^{buoyant}} = m_{air} g$$



$$F^{top} + mg = F^{bot} + F_N$$

$$F_N = (m - m_{air}) g$$

N1. T6 (E)

N1. T7 (B) How do we know there is friction?

N1. T10 (B)

N1. T8 (D, or E if air resistance)

N1. T9 (E)

~~[illegible]~~

(a centripetal force is not an indep physical force: it is a way of describing an already existing force)

N3T.2 A crate sits on the ground. You push as hard as you can on it, but you cannot move it. At any given time when you are pushing, what is the magnitude of the static friction force exerted on the crate by its contact interaction with the ground compared to the magnitude of your push F_p ?

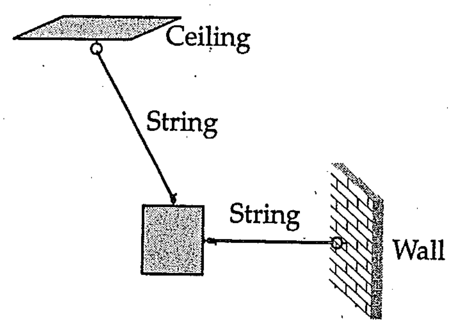
A. $F_{SF} < F_P$
B. $F_{SF} = F_P$
C. $F_{SF} > F_P$
D. $F_{SF} = 0!$
E. We do not have enough information to answer.

N3T.3 A box sits at rest on an inclined plank. How do the magnitudes of the normal force and the gravitational force exerted on the box compare? (*Hint:* Draw a picture!)

A. $F_N < F_g$
B. $F_N = F_g$
C. $F_N > F_g$
D. $F_N = 0!$
E. We do not have enough information to answer.

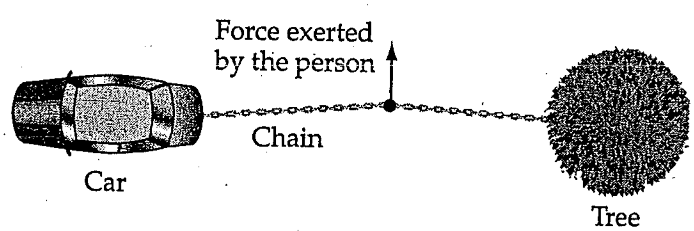
N5T.1 A weight hangs from a string but is pulled to one side by a horizontal string, as shown. The tension force exerted by the angled string is

A. Less than the hanging object's weight.
B. Equal to the hanging object's weight.
C. Greater than the hanging object's weight.

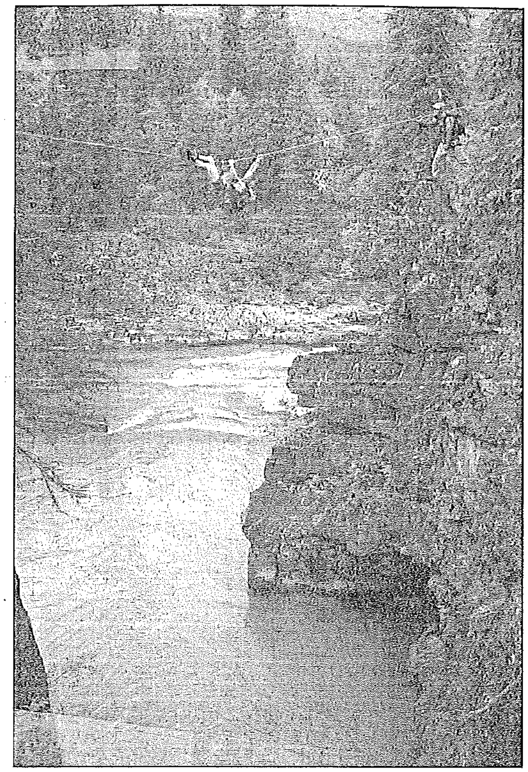


N5T.2 A person would like to pull a car out of a ditch. This person ties one end of a chain to the car's bumper and wraps the other end around a tree so that the chain is taut. The person then pulls on the chain perpendicular to its length, as shown in the picture. The magnitude of the force that the chain exerts on the car in this situation is

A. Much smaller than the force the person exerts on the chain.
B. About equal to the force the person exerts on the chain.
C. Much bigger than the force the person exerts on the chain.



*N5R.2 You are part of a research team in the deepest jungles of South America. At one point, the team has to cross a 20-m-wide gorge by stringing a rope across it and then crossing hand over hand while hanging from the rope. After someone has managed to hook the rope on a rock on the other side of the gorge, a relatively new member of the team ties the near end of the rope to a tree in such a way that the rope is very tight. A more experienced member makes the neophyte untie the rope and retie it so that there is some slack. Why? If the rope can exert a tension force of 3500 N without breaking and the heaviest member of the group has a mass of 110 kg, how much slack do you need? Is the tension on the rope greater when a person is hanging near one side of the gorge or in the middle? Assume that the rope doesn't stretch much when under tension.



N1T.1 Do the following statements about the physical world express a primarily Aristotelian viewpoint (A), do they express a primarily newtonian viewpoint (B), or are they consistent with either viewpoint (C)?

a. If you push on something, it moves. If you push twice as hard, it moves twice as fast.
b. A heavy object falls faster than a light object.
c. The moon is held in its orbit around the earth by the force of the earth's gravity.
d. If you push on an object, it moves. After you release it, it gradually comes to rest because friction drains away the force of the initial push.
e. The speed of a falling object increases as it falls.

N1T.2 A 6-kg bowling ball moving at 3 m/s collides with a 1.4-kg bowling pin at rest. How do the magnitudes of the forces exerted by the collision on each object compare?

A. The force on the pin is larger than the force on the ball.
B. The force on the ball is larger than the force on the pin.
C. Both objects experience the same magnitude of force.
D. The collision exerts no force on the ball.
E. There is no way to tell.

N1T.3 A large car drags a small trailer in such a way that their common speed increases rapidly. Which tugs harder on the other?

A. The car tugs harder on the trailer than vice versa.
B. The trailer tugs harder on the car than vice versa.
C. Both tug equally on each other.
D. The trailer exerts no force on the car at all.
E. There is no way to tell.

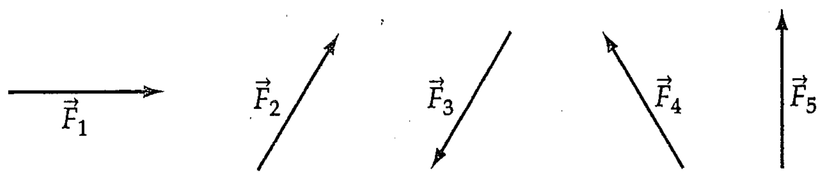
N1T.4 A parent pushes a small child on a swing so that the child moves rapidly away while the parent remains at rest. How does the magnitude of the force that the child exerts on the parent compare to the magnitude of the force that the parent exerts on the child?

A. The force on the child is larger in magnitude.
B. The force on the parent is larger in magnitude.
C. These forces have equal magnitudes.
D. The child exerts zero force on the parent.
E. There is no way to tell.

N1T.5 A spaceship with a mass of 24,000 kg is traveling in a straight line at a constant speed of 320 km/s in deep space. What is the magnitude of the net thrust force acting on this spaceship?

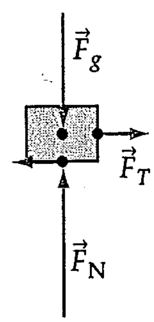
A. 7.7 MN
B. 7.7 GN
C. 75 N
D. 0.075 N
E. 0
F. Other (specify)

N1T.6 Arrows representing four forces having equal magnitudes are shown below. What combinations of these forces, acting together on the same object, will allow that object to move with a constant velocity?



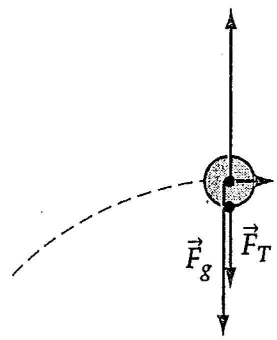
A. $\vec{F}_2$ and $\vec{F}_3$
B. $\vec{F}_3$ and $\vec{F}_4$
C. $\vec{F}_1$, $\vec{F}_2$, and $\vec{F}_4$
D. $\vec{F}_1$, $\vec{F}_3$, and $\vec{F}_4$
E. A and D
F. None of the above

N1T.7 The free-body diagram at the right is supposed to represent a box sliding at a constant speed toward the right along a tabletop as it is pulled by a string. How should we label the leftward force?



A. $\vec{F}_D$
B. $\vec{F}_{KF}$
C. $\vec{F}_{SF}$
D. The diagram is wrong: the left force should not be there at all.
E. Some other force (specify).

N1T.8 The free-body diagram below is supposed to represent a rock at the end of a string which is being whirled *clockwise* in a vertical circle. The rock is at the top of its circular path at the instant shown. How should we label the rightward force?



A. $\vec{F}_M$ (force of motion)
B. $\vec{F}_I$ (force of inertia)
C. $\vec{F}_D$
D. The diagram is wrong: the right force should not be there at all.
E. The diagram is wrong: there should be a leftward force instead of a rightward force.
F. Some other force (specify).

N1T.9 Consider again the free-body diagram in problem N1T.8. How should we label the upward force?
A. $\vec{F}_C$ (centrifugal force)
B. $\vec{F}_C$ (centripetal force)
C. $m\vec{a}$
D. $\vec{F}_I$ (force of inertia)
E. The diagram is wrong: there is no upward force.

N1T.10 Imagine that you serve a tennis ball directly forward and parallel to the ground. *Ignoring* air resistance, what is the approximate direction of the *net* force acting on the ball after it leaves your racquet?
A. Directly forward.
B. Directly downward.
C. Zero.
D. Forward and a bit downward.
E. Downward and a bit backward.
F. Some other direction (specify).