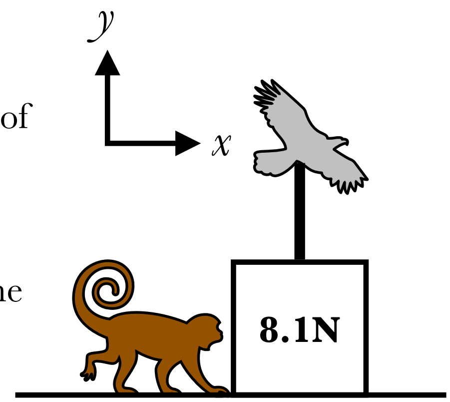
Alternate Homework Week 3

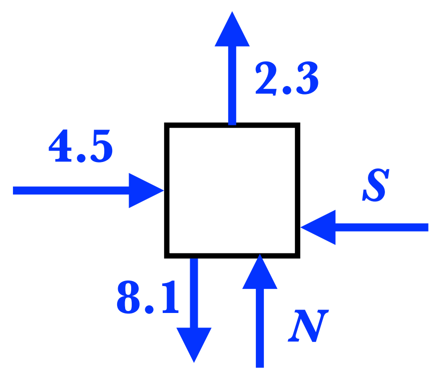
Solutions



1. A box (weight 8.1N) is sitting on a table. A hawk is pulling upward on the box with a force of 2.3N, and a monkey to the left of the box is pushing on it, with a force of 4.5N. The box is not moving.

a) In the first column of the table, list all of the forces acting on the box, indicating the type of force and its source. I've listed one to begin.

Force	*x*	*y*
Normal, monkey	**+4.5**	—
Weight, Earth	—	**−8.1**
Tension, hawk	—	**+2.3**
Normal, table	—	**+*N***
Static friction, table	**−*S***	—



b) Next to the table draw a **force diagram** of the box, with an arrow for each force in your list. Label the arrows (with numbers, initials, or whatever) so that we can tell which is which.

c) Assuming that +x is to the right and +y is upwards, fill in the magnitudes of the forces in the table, with either a + or a – depending on the direction. If you don't know the magnitude of a force, give it a variable name corresponding to the type of force it is. I've filled in the first force as an example.

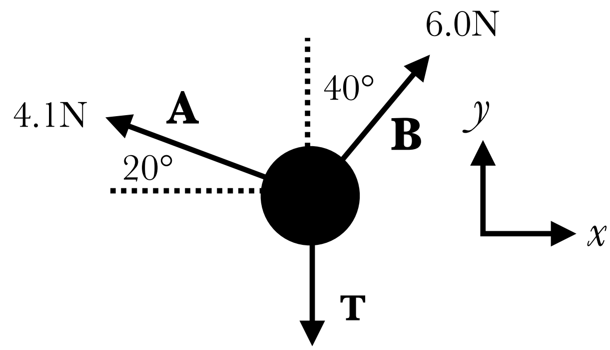
d) Solve for the two unknown variables.

$$4.5 - S = 0 \implies S = 4.5\text{N}$$

$$-8.1 + 2.3 + N = 0 \implies N = 5.8\text{N}$$

2. A ball is held stationary by three horizontal ropes, exerting the forces shown. This is being seen from above, so weight isn't relevant here.

a. Fill in the table below with the correct values.



Force	x	y
A	$-4.1\cos 20^\circ = -3.9$	$+4.1\sin 20^\circ = 1.4$
B	$+6.0\sin 40^\circ = +3.9$	$+6.0\cos 40^\circ = 4.6$
T	—	$-T$

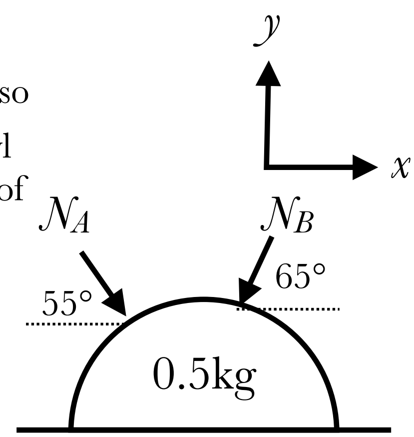
b. Solve for T.

Add up the y column to get

$1.4 + 4.6 - T = 0 \implies T = 6.0\text{N}$

Problems

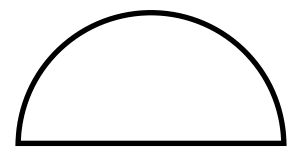
1. A hemispherical bowl (mass 0.5kg) is sitting on a slippery table, so there is *no* friction between the bowl and the table, and yet the bowl is not moving. Two normal forces, A and B, are applied to the top of the bowl. Suppose N_A = 20N.



a) Draw a force diagram and fill out the force table below.

Force	x	y
weight	——	$mg = -4.9$
normal, A	$+20\cos 55°$ = +11.5	$-20\sin 55°$ = -16.4
normal, B	$-N_B\cos 65°$ = -0.423NB	$-N_B\sin 65°$ = -0.906NB
normal, table	——	$+N_t$

Don't forget g!



The normal force isn't equal to the weight when there are other vertical forces, like the other two normal forces. Never assume N=mg in the force table.

Angles are measured from x here, so x gets the cosine!

b) Solve for N_B.

The x column only has N_B in it, so it's the perfect column to solve for N_B:

$20\cos 55° - N_B\cos 65° = 0 \implies 11.47 - 0.4226N_B = 0$

$$\implies N_B = \frac{11.47}{0.4226} = \mathbf{27.1N.}$$

c) Find the normal force of the table on the bowl.

The y column gives us the equation

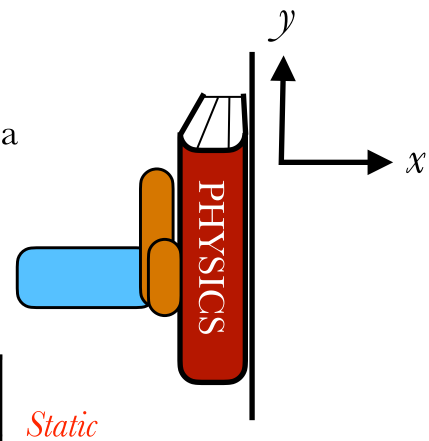
$0 = -4.9 - 20\sin 55° - N_B\sin 65° + N_t = -4.9 - 16.38 - 0.9063N_B + N_t$

Since we know that $N_B = 27.1$, we can substitute that in and solve for N_t:

$N_t = 4.9 + 16.38 + 0.9063(27.1) =$ **45.8N.**

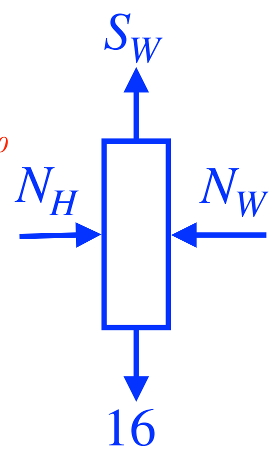
2. A hand is pushing a 16N PHYSICS book against a wall; the coefficient of static friction between book and wall is $\mu_S = 0.4$.

a) Analyze the forces on the book: fill in the force table and draw a force diagram.



Force	x	y
weight		**−16**
normal, hand	$+N_H$	
normal, wall	$-N_W$	
s. friction, wall		$+S_W$

Static friction from the wall is parallel to the wall.



b) What is the minimum force the hand must apply to the book so that it doesn't slip along the wall?

The book won't slip along the wall if $S_w \le \mu_S N_w$.

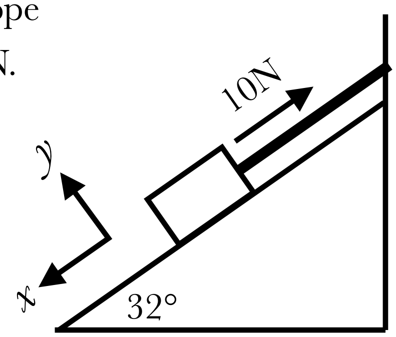
According to the x column, $N_H - N_W = 0 \implies N_W = N_H$.

According to the y column, $-16 + S_W = 0 \implies S_W = 16$.

Therefore $S_W \le \mu_S N_W \implies 16 \le (0.4)(N_H) \implies N_H \ge \dfrac{16}{0.4} = 40\text{N}$.

Therefore the normal force of the hand must be at least **40N**.

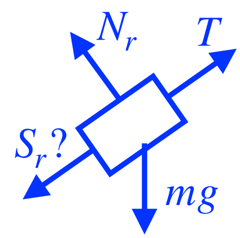
3. A 3kg block sits on a 32° ramp, as shown. It is attached by a rope to a wall at the top of the ramp, and the tension in the rope is 10N.



a) Using the tilted coordinate system, as shown, fill in the force table.

One tricky thing here: there *might* be static friction between the block and the ramp, but we can't tell if there is, or in what direction it would point. So we will assume it points in the positive direction.

Force	$\boldsymbol{x}$	$\boldsymbol{y}$
Weight is special in incline problems! **weight**	$+(3)g\sin 32^\circ$ = +15.6	$-(3)g\cos 32^\circ$ = -24.9
normal, ramp	——	$+N_r$
s. friction, ramp	S_r	——
tension, rope	-10	——



b) Solve for the unknown values.

You're given the mass not the weight.

The x column gives us

$3(9.8)\sin 32^\circ + S_r - 10 = 0 \implies S_r = 10 - 3(9.8)\sin 32^\circ = -$**5.6N**. This is a negative number, so the static friction points **up the ramp.**

and the y column gives us

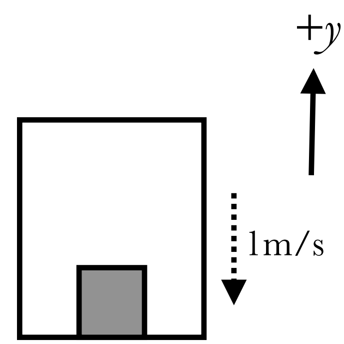
$-3(9.8)\cos 32^\circ + N_r = 0 \implies N_r = 3(9.8)\cos 32^\circ =$ **25N.**

c) What values could μ_S have? (That is, solve the inequality for it.)

$S_r \leq \mu_S N_r$, so $\mu_S \geq \frac{S_r}{N_r} = \frac{5.6}{25} = 0.224$. Thus μ_S **has to be greater than 0.224**.

The formula $S \leq \mu_S N$ never uses negative numbers.

3. An elevator is moving downward at 1m/s. It is speeding up, with an acceleration of 3m/s^2. A block with a weight of 40N sits inside the elevator.



a) What direction does the acceleration point?

The elevator is speeding up, so the acceleration points in the same direction as the velocity, that is **down** (in the negative-y direction).

b) What is the mass of the block?

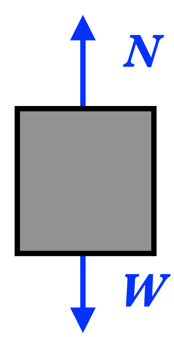
The block has a weight of 40, and so a mass of $m = \frac{W}{g} = \frac{40}{9.8} = \mathbf{4.1kg}$.

A bunch of people confused mass and weight.

c) Draw a force diagram of the block, and fill out the force table for the block below. (There are no horizontal forces so we don't need the *x* column.)

Force	***y***
weight	**−40**
normal, elevator	**+N**

$m\vec{a}$ $(4.1)(-3)$



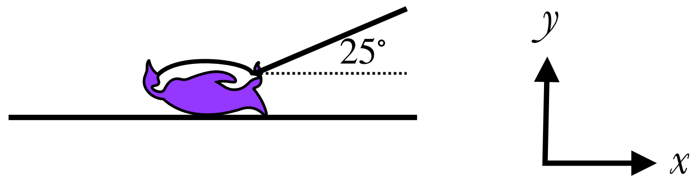
d) Solve for any unknown forces on the block.

Because the elevator is accelerating, the y column has to add up to *ma*:
$-40 + N = (4.1)(-3) \implies N = 40 - 12.3 = \mathbf{27.7N}$ is the normal force on the box from the elevator.

If you said N=40, you didn't take acceleration into account!
If you said N=52.3, you had the wrong sign for the acceleration.
I took off a point if you wrote "tension": the block feels a normal force, not tension.

1. A purple penguin is being dragged along the ground by a rope which makes a 25° angle with the horizontal. If the tension in the rope is 8N, the weight of the penguin is 30N, and the coefficient of kinetic friction between penguin and ground is $\mu_K = 0.2$.

Find the acceleration of the penguin, and say whether the penguin is speeding up, slowing down, or moving at constant speed.



Penguin	*x*	*y*
weight	——	-30
tension, rope	$+8\cos 25°$ =7.25	$+8\sin 25°$ =3.38
normal, floor	——	$+N$
k. friction, floor	$-0.2N$	——
$m\vec{a}$	$(3.06)a_x$	0

weight: 30N

mass: $\dfrac{30}{9.8} = 3.06\text{kg}$

If the penguin is being dragged along the ground, then it must be moving to the right, so the kinetic friction points to the left.

If the penguin is accelerating, it is going to be along the ground, so the horizontal acceleration is some unknown a_x but the vertical acceleration is zero.

We have two equations: $8\cos 25° - 0.2N = 3.06a_x$ $\quad -30 + 8\sin 25° + N = 0$
We solve the second equation first, since it only has one variable:
$N = 30 - 8\sin 25° = 26.6\text{N}$

And we can substitute that into the first equation to get a_x:
$3.06a_x = 8\cos 25° - 0.2(26.6) = +1.93 \implies a_x = \dfrac{+1.93}{3.06} = \mathbf{+0.63m/s^2.}$
This acceleration points to the right, in the same direction as the motion, so the penguin is **speeding up.**