#12 Mass and Weight, Newton's 3rd Law Post-class

Due: 11:00am on Wednesday, September 19, 2012

Note: You will receive no credit for late submissions. To learn more, read your instructor's Grading Policy

Exercise 4.24

The upward normal force exerted by the floor is 620 N on an elevator passenger who weighs 650 N.

Part A

What is the magnitude of the acceleration?

ANSWER:

a = 0.452 $\mathrm{m/s^2}$

Correct

Part B

What is the direction of the acceleration?

ANSWER:

- upward
- downward

Correct

Pushing a Chair along the Floor

A chair of weight 150 N lies atop a horizontal floor; the floor is not frictionless. You push on the chair with a force of F = 40.0 N directed at an angle of 41.0 ° below the horizontal and the chair slides along the floor.

Part A

Using Newton's laws, calculate n, the magnitude of the normal force that the floor exerts on the chair.

Express your answer in newtons.

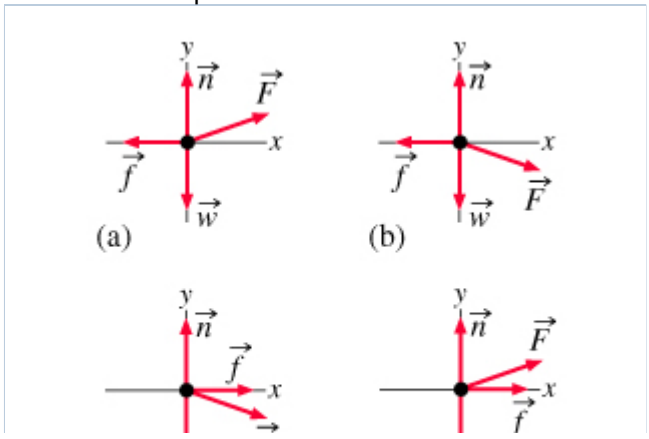
Hint 1. How to approach the problem

To solve this problem you need to focus on the forces that have a vertical component. In fact, because the direction of motion is horizontal (the chair slides along the floor), both the acceleration of the chair and the net force acting on the chair are purely horizontal. This can be true only if the net vertical force acting on the chair is zero, that is, if the normal force exerted on the chair by the floor balances all the other vertical forces acting on the chair.

Also, in any problem involving forces you should always draw a free-body diagram that shows all the forces acting on the system. To do that, choose a coordinate system and identify all the forces acting on the chair.

Hint 2. Choosing the correct free-body diagram

Let $\vec{f}$ be the friction force, $\vec{F}$ be the force you exert on the chair, and $\vec{w}$ be the weight of the chair. If you choose the *x* axis to be parallel to the floor, which free-body diagram would correctly represent the situation described in the introduction of this problem?



Hint 1. Direction of the friction force

The friction force is always directed opposite to the direction of motion.

ANSWER:

- a
- b
- c
- d

Hint 3. Find the vertical net force

Let the positive *y* axis point upward, and let n be the magnitude of the normal force exerted on the chair by the floor, w be the magnitude of the weight of the chair, and F_y be the magnitude of the *y* component of the force you exert on the chair when you push it. What is the vertical net force, that is, the *y* component of the net force, acting on the chair?

Hint 1. How to approach the problem

From your free-body diagram you can see that the normal force points upward, whereas the weight points downward. Moreover, the force that you exert on the chair has a vertical component, which is parallel to the weight.

ANSWER:

- $n - w$
- $n + w$
- $n + w + F_y$
- $n - w - F_y$

Hint 4. Find the vertical component of the force that you exert on the chair

Find F_y, the magnitude of the vertical component of the force that you exert on the chair when you push it.

Express your answer in newtons.

Hint 1. Components of a vector

Consider a vector $\vec{A}$ that forms an angle θ with the positive *x* axis. The *x* and the *y* components of $\vec{A}$ are, respectively,

$$A_x = A\cos\theta \text{ and } A_y = A\sin\theta,$$

where A is the magnitude of the vector.

ANSWER:

F_y = 26.2 N

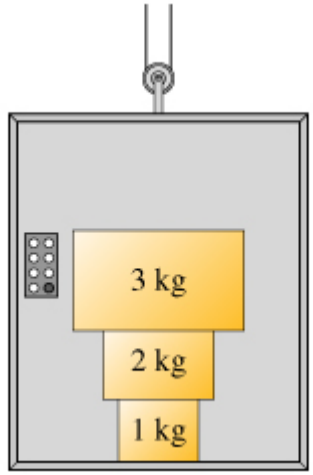
ANSWER:

n = 176 N

Correct

Blocks in an Elevator Ranking Task

Three blocks are stacked on top of each other inside an elevator as shown in the figure.



Answer the following questions with reference to the eight forces defined as follows.

- the force of the 3 kg block on the 2 kg block, $F_{3 \text{ on } 2}$,
- the force of the 2 kg block on the 3 kg block, $F_{2 \text{ on } 3}$,
- the force of the 3 kg block on the 1 kg block, $F_{\rm 3\; on\; 1}$,
- the force of the 1 kg block on the 3 kg block, $F_{1 \text{ on } 3}$,
- the force of the 2 kg block on the 1 kg block, $F_{2 \text{ on } 1}$,
- the force of the 1 kg block on the 2 kg block, $F_{1 \text{ on } 2}$,
- the force of the 1 kg block on the floor, $F_{1 \text{ on floor}}$, and
- the force of the floor on the 1 kg block, $F_{\rm floor\; on\; 1}$.

Part A

Assume the elevator is at rest. Rank the magnitude of the forces.

Rank from largest to smallest. To rank items as equivalent, overlap them.

Hint 1. Newton's 3rd law

Newton's 3rd law states that when two objects exert forces on each other, these forces are always equal in magnitude and opposite in direction.

Hint 2. Contact forces

If two objects touch each other, they exert forces on each other according to Newton's 3rd law. If two objects do not touch each other, they

cannot exert forces on each other. (Here we are assuming that the forces of gravity and electromagnetism between the objects are negligible.) For instance, the blocks with masses 1 kg and 3 kg are not in contact, therefore, the force $F_{1\text{ on }3}$ must be zero. While statements such as "block 3 applies a force to block 1 that is transferred through block 2" might sound reasonable, in physics such statements don't make sense.

ANSWER:

Correct

Part B

Now, assume the elevator is moving upward at increasing speed. Rank the magnitude of the forces.

Rank from largest to smallest. To rank items as equivalent, overlap them.

Hint 1. Effects of acceleration

If the elevator is accelerating, the net force on each block cannot be zero. However, note that the forces you are asked to compare do not comprise the net force on any of the blocks.

ANSWER:

Correct

Exercise 4.25

A student with mass 54 kg jumps off a high diving board.

Part A

Using $6.0\times10^{24}\,\mathrm{kg}$ for the mass of the earth, what is the acceleration of the earth toward her as she accelerates toward the earth with an acceleration of $9.8\,\mathrm{m/s^2}$? Assume that the net force on the earth is the force of gravity she exerts on it.

Express your answer using two significant figures.

ANSWER:

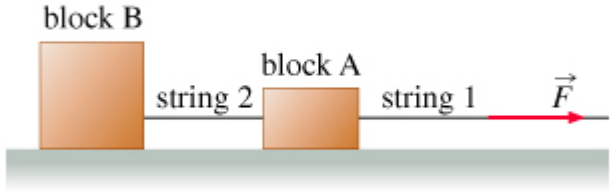
$|a|$ = 8.8×10^{-23} $\mathrm{m/s^2}$

Correct

Pulling Two Blocks

In the situation shown in the figure, a person is pulling with a constant, nonzero force $\vec{F}$ on string 1, which is attached to block A. Block A is also attached to block B via string 2, as shown.

For this problem, assume that neither string stretches and that friction is negligible. Both blocks have finite (nonzero) mass.



Part A

Which one of the following statements correctly descibes the relationship between the accelerations of blocks A and B?

Hint 1. Relative movement of the blocks

The two masses are connected (by string 2), which means, if they are being pulled, they must move together.

ANSWER:

- Block A has a larger acceleration than block B.
- Block B has a larger acceleration than block A.
- Both blocks have the same acceleration.
- More information is needed to determine the relationship between the accelerations.

Correct

Since the two blocks are connected, they won't move independently when string 1 is pulled. As block A is accelerated, its motion will impart the same acceleration to block B.

Part B

How does the magnitude of the tension in string 1, T_1, compare with the tension in string 2, T_2?

Hint 1. How to approach the problem

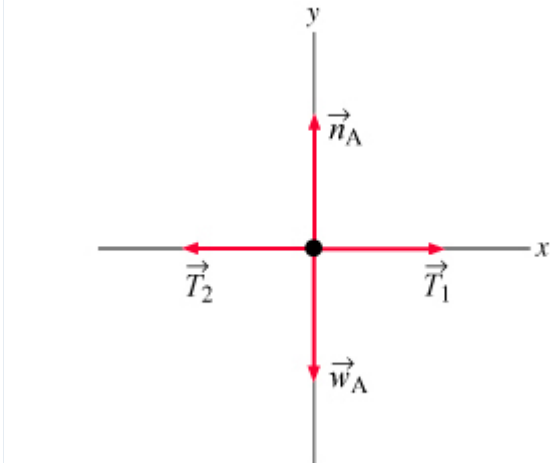
Suppose that block A has a mass m. Draw a free-body diagram for block A, then write down Newton's 2nd law for block A's horizontal motion. What is the tension T_1?

Express the tension in terms of T_2, m, and the block's acceleration a.

Hint 1. Free-body diagram for block A

Taking the positive direction to be to the right, what is the net horizontal force acting on block A? (Note that, in the figure, forces are not drawn to scale.)

Express your answer in terms of T_1, T_2, n_A, and w_A.



ANSWER:

$F = ma$ = T_1-T_2

ANSWER:

T_1 = m*a+T_2

ANSWER:

- T_1 > T_2
- $T_1 = T_2$
- T_1 < T_2
- More information is needed to determine the relationship between T_1 and T_2.

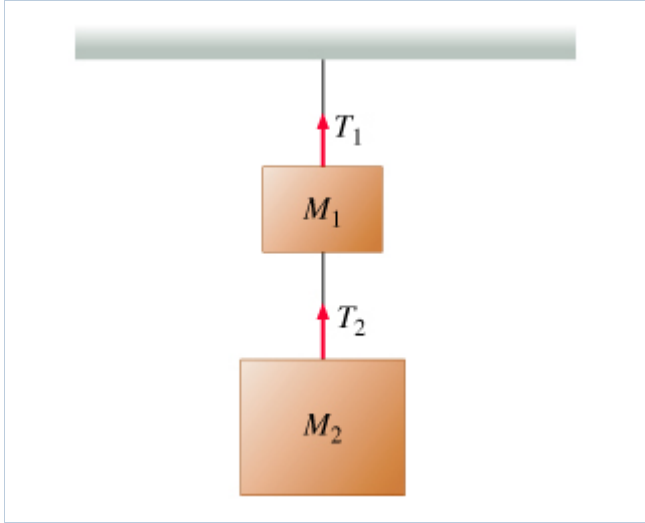
Correct

The force transmitted through string 1 (proportional to T_1) must be enough to accelerate both blocks, but the force transmitted through string 2 only needs to accelerate block B. Consider the case where block A is very heavy and block B is very light: In this case, string 2 would only need to supply a tiny amount of tension to keep the blocks connected as block A is pulled around.

Two Hanging Masses

Two blocks with masses M_1 and M_2 hang one under the other. For this problem, take the positive direction to be upward, and use g for the magnitude of

the acceleration due to gravity.



Case 1: The blocks are at rest.

Part A

Find T_2, the tension in the lower rope.

Express your answer in terms of some or all of the variables M_1, M_2, and g.

Hint 1. Free-body diagram

Isolate the lower block (mass M_2) by considering just the forces that act on it. Use Newton's 2nd law while noting that the acceleration of this block is zero.

Hint 2. Sum of forces

Write down the sum of the *y* components of all the forces acting on the lower block.

Express your answer in terms of some or all of the variables M_1, M_2, T_2 and g.

ANSWER:

\sum F_{2y} = M_2 a_2= 0 = T_2-M_2*g

ANSWER:

T_2 = M_{2}{\cdot}g

Correct

Part B

Find T_1, the tension in the upper rope.

Express your answer in terms of some or all of the variables M_1, M_2, and g.

Hint 1. Sum of forces

Write down the sum of the *y* components of all the forces acting on the upper block.

Express your answer in terms of some or all of the variables M_1, M_2, T_1, T_2, and g.

ANSWER:

\sum F_{1y} = 0 = T_1-T_2-M_1*g

ANSWER:

T_1 = gM_{1}+gM_{2}

Correct

Case 2: The blocks are now accelerating upward (due to the tension in the strings) with acceleration of magnitude a.

Part C

Find T_2, the tension in the lower rope.

Express your answer in terms of some or all of the variables M_1, M_2, a, and g.

Hint 1. Sum of forces

Apply Newton's 2nd law, \sum F_y=M_2 a, to the lower block. Write the sum of the *y* components of the forces.

Express your answer in terms of some or all of the variables M_1, M_2, T_2 and g.

ANSWER:

\sum F_{2y} = M_2 a = T_2-M_2*g

ANSWER:

T_2 = M_{2}\left(g+a\right)

Correct

Good! Now notice that acceleration acts in the tension equation the same way that gravity does. If we look at a limiting case in which the block of mass M_2 is in free fall, accelerating downward with a = -g, then the tension goes to zero.

Part D

Find T_1, the tension in the upper rope.

Express your answer in terms of some or all of the variables M_1, M_2, a, and g.

Hint 1. Sum of forces

Consider the block of mass M_1 as an isolated system and apply Newton's 2nd law, \sum F_y = M_1 a, with the value of T_2 found in the previous part.

ANSWER:

T_1 = M_{1}\left(g+a\right)+M_{2}\left(g+a\right)

Correct

The force exerted by a rope is a result of the rope's tension and points along the rope.

Score Summary:

Your score on this assignment is 91.2%.
You received 54.74 out of a possible total of 60 points.