NEWTON'S LAWS
The society which scorns excellence in plumbing because plumbing is a humble activity, and tolerates shoddiness in philosophy because it is an exalted activity, will have neither good plumbing nor good philosophy. Neither its pipes nor its theories will hold water. -- John W. Gardner

1. A rock is thrown at an angle of $35.0^\circ$ to the horizontal with a speed of 11.5 m/s. How far does it travel?

2. A 450 kg mass is accelerated at 2.5 m/s$^2$. (a) What is the force causing this acceleration? (b) If the mass of the car is doubled, what happens to the acceleration?

3. How much does a 34.5 kg gymnast weigh?
4. A 25000 kg car is pushed with a 250 N force, (a) what is the acceleration acting on the car? (b) What is the car's velocity at the end of 35 seconds?

5. A ball rolls down the ramp onto a smooth table and then onto the deck as shown. Find (a) the acceleration of the ball down the ramp and (b) the horizontal distance the ball travels when it falls off the table.

6. Okay, add these here vectors up and find the resultant. Also find the angle it makes with the x axis.
Draw the free body diagrams for the pictures below.

1)

<table>
<thead>
<tr>
<th>Forces on Neil Diamond</th>
<th>Forces on the bass</th>
<th>Kid on slide</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Neil Diamond" /></td>
<td><img src="image2" alt="Bass Player" /></td>
<td><img src="image3" alt="Slide" /></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Forces on the poor dog</th>
<th>Forces on the lucky sled</th>
<th>Taking Off...Hovering...Landing</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image4" alt="Poor Dog" /></td>
<td><img src="image5" alt="Lucky Sled" /></td>
<td><img src="image6" alt="Hot Air Balloon" /></td>
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</tbody>
</table>

2) To the right is a car of mass 1000 kg. Answer the following questions.
   a) What is the weight of the car?

   ![Car Diagram](image7)

   

   b) With what force does the ground push the car up at?

   ![Car Diagram](image8)

   

   c) If the engine pushes the car forward with a force of 8000 N, and friction pushes backward at 1000 N, what is the net force on the car? What is the acceleration of the car?

   ![Car Diagram](image9)

   

   d) If the driver now puts the car on cruise control (constant velocity), and the engine pushes the car forward with a force of 5000 N, what is the net force on the car? What is the acceleration of the car? What is the force of friction?

   ![Car Diagram](image10)

   

   e) Draw a free body diagram for parts “c” and “d”.

   ![Car Diagram](image11)
3) Draw the free body diagrams, and determine the force of the cable attached to the elevator in the conditions below. The mass of the elevator is 200 kg.

<table>
<thead>
<tr>
<th>a=5m/s² up</th>
<th>a=5m/s² down</th>
<th>constant speed</th>
<th>free fall</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="#" alt="Diagram" /></td>
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<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
</tr>
</tbody>
</table>

3) Draw the free body diagrams, and determine the acceleration of the elevator in the conditions below. The mass of the elevator is 500 kg.

<table>
<thead>
<tr>
<th>F_{cable}=6500N up</th>
<th>F_{cable}=3500N up</th>
<th>F_{cable}=5000N up</th>
<th>F_{cable}=0 N</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
</tr>
</tbody>
</table>
1. A frog jumps at an angle of 42.5° to the horizontal with a speed of 13.5 m/s. How far does it travel?

2. A 450 kg mass is accelerated at 2.5 m/s². (a) What is the net force causing this acceleration? (b) much distance will have been covered after 3.5 s


4. A boy pushes a lawnmower. The handle of the lawn mower makes an angle of 22° with the horizontal. If the boy pushes with a force of 135 N, what are the horizontal and vertical components of the force?
5. A 46.5 kg traffic light hangs from two cables which are at the angles shown. Calculate the tensions in the two cables.

6. A 50.5 kg traffic light hangs from two cables which are at the angles shown. Calculate the tensions in the two cables.
I long to accomplish a great and noble task, but it is my chief duty to accomplish small tasks as if they were great and noble. -- Helen Keller

1. A crow flying horizontally at a speed of 14.0 m/s drops a walnut. The walnut falls to the ground in 3.50 s. (a) How high was the crow flying? (b) how far horizontally does the walnut travel before it hits the deck?

2. When you walk along the sidewalk, you push the earth and the earth pushes you. How come no one notices that you pushed the earth?

3. How does a rocket work in space if there is no air to push against?

4. A crate rests on very low friction wheels. The crate and the wheels and stuff have a weight of 865 N. You pull on the rope with a force of 145 N. What is the acceleration of the system? How far will it move in 2.00 s?
5. A 34.5 kg block rests on the ramp as shown in the drawing. What is the tension in the line that is connected to the top of ramp?

6. A 7.00 kg ball rolls down a 17.5° ramp. (a) What is the acceleration of the ball? (Ignore friction) (b) If the ramp is 2.00 m long, how much time to reach the bottom?

7. A barge is towed at a constant velocity by two mules as shown in the drawing. (a) What is the net force acting on the barge when the tow begins if the frictional force that must be overcome is 1250 N? (b) Later the barge is moving at 2.5 km/h, what is the net force acting on it?
8. A 4.50 kg block rests on a smooth ramp as shown. It is attached to a 4.20 kg block by a very low mass string that is run over a low friction pulley. (a) In what direction will the blocks travel? And (b) What will be the acceleration of the blocks when the system is released?

9. Two masses are connected by a light string that runs over a frictionless pulley as shown. What is the acceleration of the system when the masses are released and allowed to move?
1. Okay, a small insect smashes into the windshield of your car while you are zooming down the interstate. (a) Which exerts the larger force; the bug on the car or the car on the bug? So how come? (b) Which experiences a larger acceleration; the bug or the car? How come?

2. A ultra low friction pulley deal is as shown. The two weights experience an acceleration of 0.450 m/s^2. Find the mass of the second weight.
3. A big dump truck is at rest on a section of road that is at an angle of 5.00° to the horizontal. The truck's mass is 15 500 kg. What force must the brakes exert to keep the truck from rolling down the sloped road?

4. Three masses are connected by a light string that passes over a frictionless pulley as shown. (a) What is the acceleration of the system? (b) What are the tensions in the string?
5. A soccer ball is kicked at an angle of 32.5° with a velocity of 21.5 m/s. (a) draw a FBD of the thing. Good, now find: (b) the time of flight for the soccer ball, (c) the distance the ball travels, and (d) the height of the soccer ball after 1.50 s.

6. Find the tension in each cable supporting the 600.0 N cat burglar.
In the end, we will remember not the words of our enemies, but the silence of our friends. -- Martin Luther King, Jr.

1. Blocks 1 and 2 of masses $m_1$ and $m_2$, respectively, are connected by a light string, as shown above. These blocks are further connected to a block of mass $M$ by another light string that passes over a pulley of negligible mass and friction. Blocks 1 and 2 move with a constant velocity $v$ down the inclined plane, which makes an angle $\theta$ with the horizontal. The kinetic frictional force on block 1 is $f$ and that on block 2 is $2f$. (year 2000 AP Exam Quest)

(a) On the figure below, draw and label all the forces on block $m_1$.

Express your answers to each of the following in terms of $m_1$, $m_2$, $g$, $\theta$, and $f$

(b) Determine the coefficient of kinetic friction between the inclined plane and block 1.
(c) Determine the value of the suspended mass $M$ that allows blocks 1 and 2 to move with constant velocity down the plane.

(b) The string between blocks 1 and 2 is now cut. Determine the acceleration of block 1 while it is on the inclined plane.

2. Two 10.0 kg masses are hanging from the ceiling of an elevator that is accelerating upward at 2.00 m/s$^2$. What is the tension in each rope?

3. A 250.0 kg crate is being pulled across the floor at a constant speed with a rope that makes an angle of 22.0° to the horizontal. If the force applied is equal to 875 N, what is the coefficient of kinetic friction?
4. In the ramp system shown, a 7.00 kg mass is attached to a 6.50 kg mass by a light string that is threaded through a low friction pulley. The 7.00 kg mass accelerates up the ramp when the 6.50 kg mass is released. (a) Draw a FBD for each object and (b) find the acceleration of the system if the coefficient of kinetic friction between the 7.00 kg mass and the plane is 0.280.
A baby is God's opinion that life should go on. — Carl Sandburg

1. A small weather rocket weighs 15.7 N. (a) What is the rocket's mass? (b) The rocket fires its engine when it is dropped from a balloon at high altitude. If the rocket has a thrust of 109.2 N, what is the acceleration on the rocket?

2. A boy pulls a 47.5 kg crate with a rope. The rope makes an angle of 28.0° to the horizontal. The coefficient of kinetic friction for the crate and the deck is 0.300. The boy exerts a force of 185 N. What is the acceleration of the crate?
3. Two of these here masses are connected by a very light weight string that passes over your basic very low friction pulley. The mass on the left is 3.25 kg. The 3.25 kg mass accelerates upward at 0.345 m/s². What is the mass on the other side of the pulley?

![Diagram of two masses connected by a string over a pulley.]

3.25 kg

4. A disturbing weight hangs suspended as shown in the drawing. Find the tensions in the two strings.

![Diagram of a weight suspended by two strings at different angles.]

119 kg
5. An inclined plane has an 8.00 kg mass resting on it. The plane makes an angle of 28.0° to the horizontal. The coefficient of kinetic friction is 0.342. A low-mass string is attached to the weight and runs over one of them really good low friction pulley deals where it is attached to a 6.50 kg mass.

(a) What is the tension in the string?
(b) What is the acceleration of the system?
(c) Does the 8.00 kg mass go down the ramp or up the ramp?

![Diagram of inclined plane with masses](image)

6. A 2.25 kg ball experiences a net force of 965 N up a ramp as shown. Once the ball reaches the top of the ramp, the force no longer acts. The force acts over a distance of 1.50 m on the ramp. Find the horizontal distance $x$ that the ball travels before it hits the deck. The top of the ramp is 4.50 meters above the deck below.

![Diagram of ball on ramp](image)
7. Two small blocks, each of mass $m$, are connected by a string of constant length $4h$ and negligible mass. Block $A$ is placed on a smooth tabletop as shown and block $B$ hangs over the edge of the table. The tabletop is a distance $2h$ above the floor. Block $B$ is then released from rest at a distance $h$ above the floor at time $t = 0$.

(a) Determine the acceleration of block $B$ as it descends.
(b) Block $B$ strikes the floor and does not bounce. Determine the time $t_1$ at which block $B$ strikes the floor.
(c) Describe the motion of block $A$ from time $t = 0$ to the time when block $B$ strikes the floor.
(d) Describe the motion of block $A$ from the time block $B$ strikes the floor to the time block $A$ leaves the table.
(e) Determine the distance between the landing points of the two blocks.
Our lives begin to end the day we become silent about things that matter. --Martin Luther King, Jr.

1. A ball is kicked at an angle of 38.0° to the horizontal with a speed of 15.8 m/s. How far does it travel?

2. What is the mass of a 235 N acrobat?

3. A 25.6 kg rocket accelerates upward at 105 m/s². What is the thrust pushing it up?
4. When you jump into the air, you push the earth away from you and the earth pushes you away from it. How come no one notices that you pushed the earth?

5. A 12 250 kg boulder hangs from two cables which are at the angles shown. Calculate the tensions in the two cables.

6. Two masses are connected by a light string which passes over a frictionless pulley as shown. (a) What is the acceleration of the system? (b) What are the tensions in the string?
7. You pull on a 98.0 kg bag of wild bird seed and drag it across the deck. If the coefficient of kinetic friction for the bag on the deck is 0.445, what force must you apply to move the thing at a constant speed?

8. A Find the acceleration of the system shown in the drawing if the coefficient of kinetic friction between the 7.00 kg mass and the plane is 0.280.

![Diagram of a system with a 7.00 kg mass and a 11.0 kg mass connected by a cord over a pulley, with a 43.0° angle.]

9. A retired policewoman pushes on a 77.2 kg crate with a pole. The pole makes an angle of 32.0° to the horizontal. The coefficient of kinetic friction for the crate and the deck is 0.350. The policewoman exerts a force of 535 N. What is the acceleration of the crate?

10. Why do all objects fall at the same speed (ignoring air resistance)?

11. The first law says that no force is required to maintain motion. Fine, then how come you have to keep pedaling your bicycle to keep it moving?
12. What is the difference between mass and weight?

13. Explain, in terms of Newton's laws, the magician's trick of pulling a tablecloth out from under a bunch of dishes and cups and stuff without disturbing them.

14. What net force is required to accelerate a 135 000 kg aircraft from rest to a speed of 35.0 m/s in 11.0 s?

15. A wise guy you know poses this problem to you, "A horse pulls on a cart, exerting a force on it. The cart exerts an equal and opposite force on the horse. So if the forces are equal, then the net force is zero and the horse cannot pull the cart." What is wrong about this set of particulars? [I.e., why can the horse pull the cart?]
AP Physics – Atwood Lab

My job is to comfort the disturbed and disturb the comfortable -- Unknown

Rig up an Atwood machine using a low friction pulley, a ringstand, and a clamp as shown in the drawing below.

A light string should be run over the pulley. Attach a paper clip to the two bitter ends of the string. Add five large washers to the paperclips on each side. The masses must be balanced, and this may not happen. It could be that the large washers on one side could have a slightly different mass than the ones on the other side. Fix this by adding small paperclips to the smaller mass until it is equal in mass to the larger one. Once it is all set, the two masses should not move when released. Measure and record the mass on each side.

Take one small washer and add it to one of the paper clips tied onto the string. You now have a genuine Atwood machine. When released the system will accelerate.

What you need to do now is to use the thing to figure out the mass of the small washer.

Your pal, General Physics, will be happy to provide you with suitable measuring devices – you have but to ask.

Do not measure the washer’s mass directly; the objective is to determine the mass by analyzing the motion of the thing when you release it.

Once you’ve calculated the mass of the small washer, feel free to actually measure it for comparison with your experimental value.

May the force be with you.
Coffee Filter Lab

1) Draw the free body diagram of the filter after it has fallen for about two seconds (when \( v = \text{constant} \)). What is the net force?

2) Was the net force ever not zero? If so, when?

3) Explain why objects experience terminal velocity when falling.

4) Can an object experience a terminal velocity in a vacuum? Why or why not?

5) Calculate the magnitude of the frictional force if 35 filters fell at a constant velocity?

6) Calculate the magnitude of the frictional force if 35 filters fell with an acceleration of 5.2 m/s\(^2\)?