Teacher Guide for BLOSSOMS Lesson:

Recognizing Forces: Does the floor know when you put on weight?

Based on Energizing Physics Lesson 3.04: What forces are acting on you?

Overview

Lesson Type: Interactive Activity
Grouping: Groups of 3 or 4 are best

Materials: Notebook, bathroom scale (preferably one in SI units)

Timing: 45-50 minutes

Big Question: How do we determine and model the forces act on an object?

What Takes Place:
The lesson introduces students to forces by first having them calculate the force of gravity acting on an object as well as how the normal force from the ground is related to gravity with the 3rd Law of Motion. Students then learn to build their own force diagrams using a bathroom scale.

Key Terms:
force of gravity (i.e. weight), normal force, Newton's 3rd Law of Motion, force diagrams, net force

Learning Target (Energizing Physics 3.04):

a. Quantify the force of gravity using mass (m) and gravitational field strength (g) and other forces using Newton's Laws of Motion.
b. **Graphically represent forces acting on an object with a force diagram.**
c. Determine the net force acting on an object using a force diagram.

Focus on Understanding:
Forces challenge students. They have difficulty identifying forces acting on an object in a certain situation and then developing a diagram to model those forces. Even if they do correctly identify the forces, their sloppy diagrams are tough to read. Over time, as you push them to draw clear, organized diagrams, they will get better at these diagrams and recognize the value to the process.

At first students find normal forces puzzling. They begin to appreciate them after considering what would happen without them. In many instances, the normal force equals the force of gravity and students incorrectly believe this is always true. The lesson presents multiple situations where the normal force does not equal the force of gravity to take on this issue. Students also incorrectly think that the scale reads the the weight when it really reads the normal force.

Students typically incorrectly identify the normal force and force of gravity as a third law pair. However, since they (a) act on the same object, (b) are not always equal and opposite, and (c) don't need to coexist, they are not a 3rd Law Pair. You will need some time to discuss this distinction and how it fails all three requirements.

While not a force, net force is a useful concept, critical to understand Newton's 1st and 2nd laws. Be sure students know it is not a particular force and doesn't go on the force diagram. Net force is the result of all the forces. Also, students need to follow the sign conventions (+ and -) correctly to obtain an accurate net force.

Level	Lesson Assessment Guide
4	Meets level 3 and can use the force diagram to accurately describe the resulting motion of an object.
3	Able to identify forces and build accurate force diagrams for a variety of situations.
2	Can begin to draw force diagrams but diagrams may have one of the following issues: • F_{Normal} always equals $F_{gravity}$ • F_g changes for an object of constant mass. • Diagrams of sloppily developed or drawn incorrectly.
1	Diagrams have two or more of the issues described in "2".
0	No student data.

Solution Key to Questions Posed in Video

1. As you sit in your chair, what forces are acting on you?

(Answer) The force of gravity pushes you down and the force of the chair pushes you up.

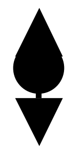
2. (Question) Take a few minutes to calculate how many newtons the gravity pulls down on Jack?

*(Answer) We know that $F_{Gravity}$ = m(g) since the kg in mass cancels out with the kg in the gravitational strength's N/kg to get N, the unit that measures force. In this case $F_{Gravity}$ = (50)(9.8) = **490 N**.*

3. (Question) Which of these force diagrams accurately represents the forces acting on Jack as he stands on the ground.

(Answer) Only diagram D shows equal-sized arrows properly directed, with labels of the type and amounts.

F_N=490 N



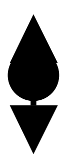
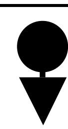
F_g=490 N

4. (Question) What is Jack's vertical net force as he stands on the ground? Horizontal net force?

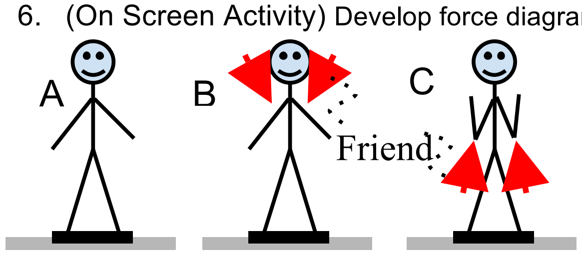
(Answer) Jack's ***vertical F_{Net} = 0*** *because 490 + (-490) = 0. Since there are no horizontal forces acting on him, his* ***horizontal F_{Net} = 0.***

5. (On Screen Activity Questions) A bathroom scale reads 600.0 N when Diego stands on it.
   a. Draw Diego's force diagram.
   b. What is Diego's mass?
   c. Suddenly the floor disappears. Draw Diego's new force diagram.
   d. After the floor disappears, what is Diego's net vertical force? Net horizontal force?

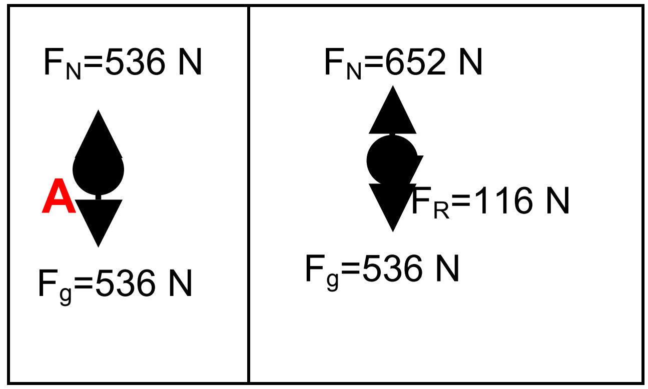
(Answers)

F_N=600 N  F_g=600 N a)	b) $F_{gravity}$ = m (g), 600 = m (9.8) m_{Diego} = 61.2 kg m_{Diego}=61 kg	 F_g=600 N c)	d) $F_{net,vert}$=-600 N $F_{net, hori}$=0 N

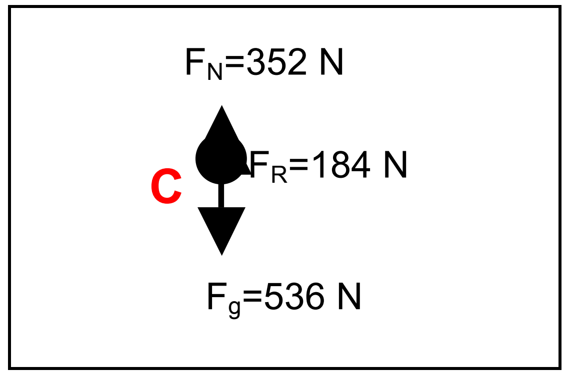
6. (On Screen Activity) Develop force diagrams for the three situations shown in the drawings below.



(Answers) The scale reading gives the student the normal force in all three cases. Example diagrams for A and B are shown here. As you can see, with no other forces, the upward normal force equals the downward force of gravity. If your friend pushes down on you, the normal force increases to balance out gravity and the downward push.



A minor adjustment to the procedure with the bathroom scale results in a normal force lower than the force of gravity. In this case, the friend's force helps out the normal force in supporting the force of gravity.



7. (Question) What about the normal force and gravity acting on you? Are these two forces a third law pair?

(Answer) No, It actually fails all three tests. As you all found out, the normal force is not always equal to gravity. They don't always coexist - when you jump off the ground, the normal force goes away but gravity does not. Lastly, they both are applied to you. Third law pairs must each act on different objects.

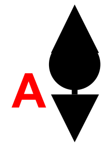
Teacher note: Many students will say yes, even though these forces actually fail all three requirements. The video discusses one third law pair (the force of gravity on you and the force of gravity you apply to the Earth) but you could also talk about the normal force from your shoes onto the ground the the normal force on your feet from the ground.

Extra Practice

1. (*Basic review*) A scale reads 580.0 lbs while Jenny stands on it.
    a. Draw Jenny's force diagram.
    b. Her friend comes by and applies a force to Jenny so the scale now reads 500.0 lbs. Draw her new force diagram.
    c. Her friend now applies a force so the scale reads 650.0 lbs. Draw her new force diagram.
    d. What is Jenny's mass in kilograms?

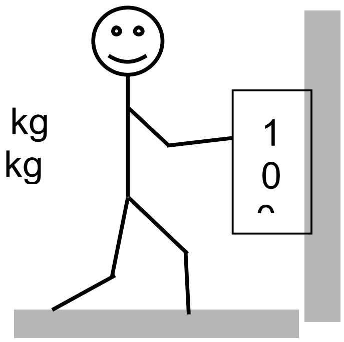
(Solution)

G	Scale reading 1 = 580.0 lbs, Scale reading 2 = 500.0 lbs, Scale reading 3 = 650.0lbs, g = 10 N/kg

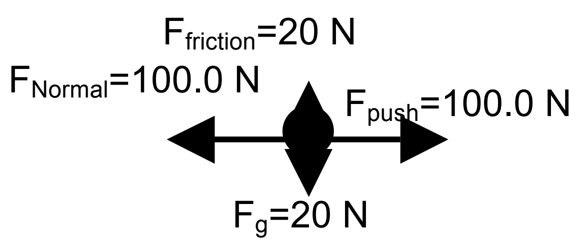
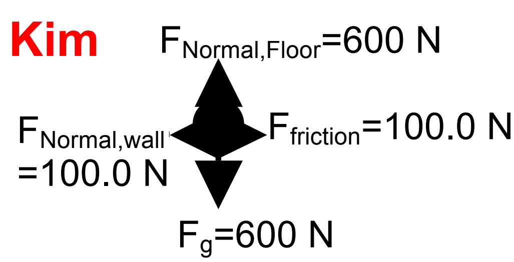
<table>
<tr><td>U</td><td>a-c) Force diagrams d) Jenny's mass</td></tr>
<tr><td>I</td><td>F_{net}=0 N, $F_{net}=F_N+F_g+F_{push}$</td></tr>
<tr><td>D</td><td>Since Jenny is at rest and only F_g and F_N act on her: F_g=580 N
<table>
<tr><td>a) Force diagram on Jenny just have F_g and F_N with equal size arrows since Jenny is at rest.</td><td>
</td></tr>
<tr><td>b) Since the normal force is less than the force of gravity, Jenny's friend must be pushing upward:
$F_{net} = F_N + F_{push} + F_g = 0$
$500 + F_{push} - 580 = 0 \rightarrow F_{push} = 80\ N$</td><td>
</td></tr>
<tr><td>c) Since, the normal force is more than the force of gravity, Jenny's friend must be pushing downward:
$F_{net} = F_N + F_{push} + F_g = 0$
$650 + F_{push} - 580 = 0 \rightarrow F_{push} = -70\ N$</td><td>
</td></tr>
</table>
d) Jenny's Mass: F_g = mg → $m = \frac{Fg}{g} = \frac{580\ N}{9.8\ N/kg} = 59\ kg$</td></tr>
<tr><td>E</td><td>This problem reviews the work done in the video.</td></tr>
</table>

2. (*Apply ideas to a new situation*) Kim holds a scale at rest up against the wall as shown.
    a. Draw the scale's force diagram.
    b. Draw Kim's force diagram.

m_{Kim}=60.0 kg
m_{scale}=2.0 kg



(Solution)

<table>
<tr><td>G</td><td>Scale reading = 100.0 N, Scale mass = 2.0kg, Kim mass = 60.0kg, g = 10 N/kg</td></tr>
<tr><td>U</td><td>Force diagrams of Kim and scale</td></tr>
<tr><td>I</td><td>$F_{gravity}$ = mg, F_{net}= 0 N since at rest</td></tr>
<tr><td>D</td><td>
<table>
<tr><td>Calculations</td><td>Force Diagram</td></tr>
<tr><td>a) Forces on the scale:
$F_{gravity\ scale}$ = 2.0 x 10 = 20 N
0 = -20 + F_{fric}
F_{fric} = 20 N
F_{push}= 100 N, F_{normal}= 100 N</td><td>
</td></tr>
<tr><td>b) Forces on Kim:
$F_{gravity\ Kim}$ = 60 x 10 = 600 N
0 = -600 + F_{normal}
F_{normal} = 600 N
F_{push}= 100 N, F_{normal}= 100 N</td><td>
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<tr><td>E</td><td>This problem takes the idea of normal force to deeper understanding, since there are horizontal normal forces and a third law pairs involved in the scale-Kim interaction.</td></tr>
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