NAME: ___________________

Chapter 4: Newton's First Law

Text:
Chapter 4
Think and Explain: 1-12
Think and Solve: 2

Vocabulary:
force, Newton's 1st law, equilibrium, friction, inertia, kilogram, newton, law of inertia, mass, weight, net force, volume, normal force, support force, free body diagram (force diagram), tension

Equations:

$$F_W = mg$$

Constants: $g = \pm 10\ m/s^2$

Key Objectives:
Concepts
- ❑ Understand the role of Aristotle, Galileo, and Newton in our understanding of motion.
- ❑ State and explain Newton's First Law of Motion.
- ❑ Describe the concept of inertia.
- ❑ State the difference between mass and weight.
- ❑ Define equilibrium and recognize objects in equilibrium.
- ❑ Create free body diagrams for objects in equilibrium and state what forces are acting on the objects.

Problem Solving
- ❑ Solve for the mass of an object when given the weight.
- ❑ Solve for the weight of an object on a planet when given the mass and the acceleration due to gravity on that planet.

*Lab 4-1: **Weight & Mass***

Purpose:
1. To determine the relationship between the weight of an object and its mass.
2. To make a graph of Weight vs Mass for a variety of different objects.

Equipment:
Electronic balance (in grams) Spring balances or Force Probes (in Newtons)

Procedure:
1. Looking around the room and in your backpacks, find a variety of objects to measure.
2. Use the electronic balance to find the mass of each object. Convert grams to kilograms.
3. Use the spring balances to find the weight of each object in Newtons.

Data:

Object	*Mass (kg)*	*Weight (N)*

Object	*Mass (kg)*	*Weight (N)*

Analysis:
1. Graph Weight vs. Mass. Weight should be on the y-axis. Add a best fit line.
2. Sketch your graph below and write the equation of the best-fit line using meaningful variables:

Questions:
1. What is the y-intercept of your graph? __________Why is this significant?
2. What is the slope of your graph? __________What does this number remind you of?
3. What is the relationship between weight and mass? Make this good!

Mass & Weight Concepts

1. Mass and weight are two very different concepts that are often confused. Give the definitions of each in the space below:
   MASS:

   WEIGHT:

2. Mass is measured in _______________ and weight is measured in ________________.

3. Which is the same, no matter where you are in the universe?

4. Which depends on your location, and can change from place to place and planet to planet?

5. On the earth, a mass of 1 kg weighs about __________.

6. Gravity on the moon is about 1/6 that of the earth. Would it be [easier/harder/just the same] to lift a rock on the moon that was very heavy on the earth? Why?

7. Would it be [easier/harder/just the same] to push a heavy car on the moon compared to pushing it on the earth? Why?

All the questions below are on the earth:

8. How much does a 2 kg object weigh?

9. How much does a 5 kg object weigh?

10. How much does a 12.5 kg object weigh?

11. What is the mass of an object that weighs 30 N?

12. What is the mass of an object that weighs 70 N?

13. What is the mass of an object that weighs 155 N?

14. A rock has a mass of 2.5 kg on the earth. What is its mass in the middle of outer space?

15. A rock weighs 17 N on the earth. How much does it weigh in the middle of outer space?

16. If you travel from planet to planet, your ______________ stays the same no matter where you are, but your ______________ changes depending on the planet you are on.

Mass & Weight Problems

$g_{earth} = 10\ m/s^2$ $g_{moon} = 1.6\ m/s^2$ $g_{mars} = 3.7\ m/s^2$ $g_{Jupiter} = 24.8\ m/s^2$

1. What is the force of gravity on a person of mass 55 kg on the earth?

2. How much does a 75 kg person weigh on the earth?

3. How much would a 75 kg person weigh on the moon?

4. What is the mass of a person who weighs 950 N on the earth?

5. What is the mass of a person who weighs 140 N on the moon?

6. Object A weighs 100 N on the earth while Object B weighs 100 N on the moon.
   a. Which has more mass?

   b. Which would be more difficult to pick up and hold? Why?

   c. Which would be more difficult to push sideways? Why?

7. How much would a container of milk that weighs 20 N on the earth weigh on Jupiter?

8. If a person weighs 1500 N on Jupiter, how much would they weigh on Mars?

*9. An astronaut on a far away planet drops a 50 kg backpack from a height of 1.5 meters. It falls for 2.2 seconds. How much does the backpack weigh on that planet?

Answers:` *1) 550 N* *2) 750 N* *3) 120 N* *4) 95 kg* *5) 87.5 kg*
6. a) B *b) same; same weight* *c) B; more mass*
7) 49.6 N *8) 224 N* *9) 31 N (g = 0.62 m/s^2)*

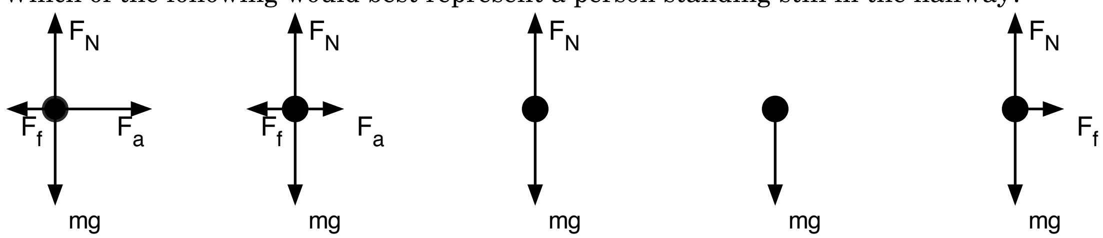
Newton's 1st Law Force Diagrams

A "Free-Body Diagram" is just a sketch showing all the forces acting on an object, but taking care to label the forces correctly and show the correct directions.

Common forces that may be present:

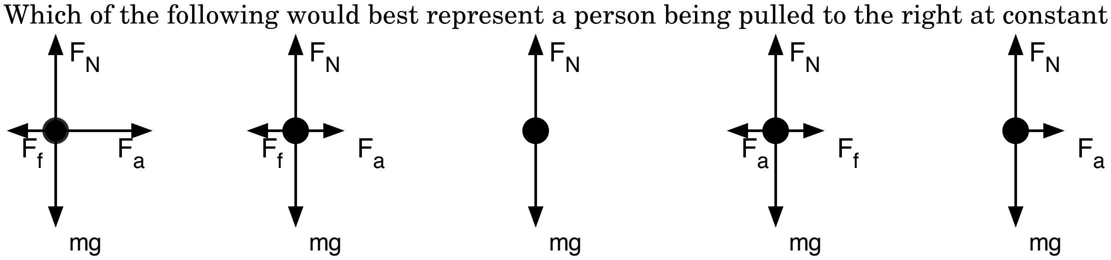
F_W – Force of weight (force of gravity)
F_T - Force of tension (force in a string or a cable)
F_N – Normal force (support force of the ground on an object)
F_f or F_{drag} – Force of friction or force of air drag
F_{lift} – Lift force of the propellers or wings of an airplane
$F_{applied}$ – Force applied to an object.

1. Which of the following would best represent a person standing still in the hallway?



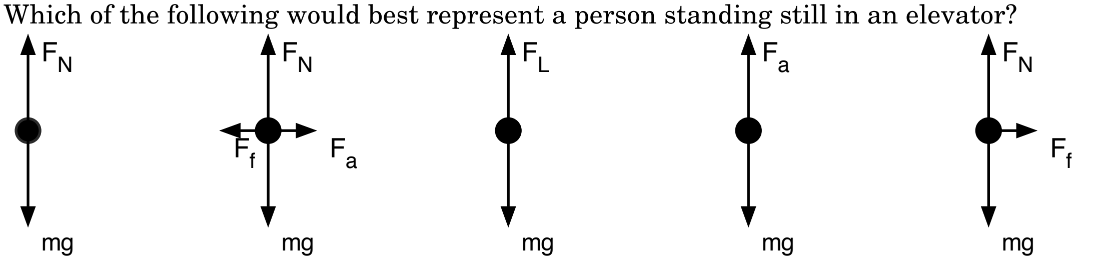
a. b. c. d. e.

2. Which of the following would best represent a person being pulled to the right at constant speed?



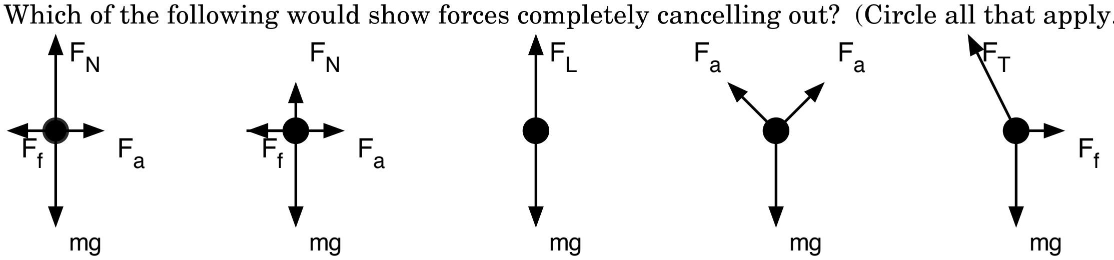
a. b. c. d. e.

3. Which of the following would best represent a person standing still in an elevator?



a. b. c. d. e.

4. Which of the following would show forces completely cancelling out? (Circle all that apply.)



a. b. c. d. e.

Newton's 1st Law Force Diagrams

For each of the following, sketch a "Free Body Diagram," which is a labeled diagram of all the forces acting on the object.

1. A car traveling to the right at a constant speed.

2. An airplane flying to the right at constant velocity.

3. A helicopter hovering above the ground.

4. A person riding in an elevator moving up with constant speed.

5. A helicopter coming down at constant speed.

6. A mass m suspended from two cables both at 20° from vertical.

7. A mass m suspended from two cables. One cable is at 20° from vertical and the other is at 70° from vertical.

8. A student pushing a fellow student on a skateboard to the left at a constant speed.

9. What do all of those examples have in common? How does this relate to Newton's 1st Law?

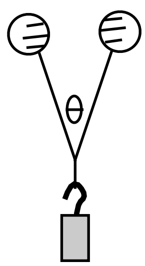
Lab 4-2: ***Tension in a String***

Purpose:
1. To determine the tension in two strings holding a mass when the two strings make the same angles and when the two strings make complimentary angles.
2. To determine the relationships between the angles of the strings and the tensions in the mass for 2 strings holding a mass in equilibrium.

Materials: 2 Force Probes or Spring Scales; 2 stands with clamps & small rods; supplied mass; string; protractor

Procedure/data:

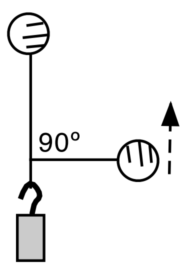
Part 1: Qualitative Analysis



1. Hold the mass by the ends of the two strings. Starting off with your hands together (so that the angle in the picture is as small as possible) slowly try and make the angle as big as possible.
   a. Can you say anything about the force needed to make the angle bigger?

   b. Did the mass change its weight at all? Did the total force pulling down ever increase?

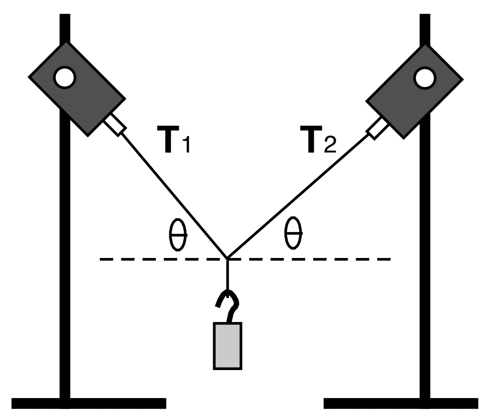
   c. Could you make it so that the angle is 180°?



2. Now hold it by one string, and keep the other string perpendicular to the first. Is there any tension (force) in the string that is horizontal?

3. Slowly pull up on the string that is horizontal. In which string is there more force?

Part 2: Quantitative Analysis



1. Now hang the mass by attaching the two strings to the two force probes/spring scales. To use the force probes, just start LoggerPro; the bottom left corner should be two boxes with the two different forces. Pull on the probes to make sure you know which force reading goes with which probe. If needed, zero the force probes by clicking on the blue ⃠ button, which is next to the green collect button.)
2. Now hang the mass from <u>both</u> probes/scales at the same time. Do your best to keep the strings going straight up. (That means the angles θ are both 90°.) Record the forces (tensions) in the data table.
3. Adjust everything so that both angles are 60° and record the tensions (forces) in the table below.
4. Adjust everything so that both angles are 45° and then 30° and record the tensions both times. You should probably hold the stands so they don't fall.

Mass suspended: _________ kg

Angle θ	*Tension* T_1	*Tension* T_2
90°		
60°		
45°		
30°		

*Lab 4-2: **Tension in a String***

Conclusion:

1. In all of these trials, what must be the net force on the mass? Support your answer.

2. What was the weight of the suspended mass?

3. In all of these trials, what must be true about the sum of the vertical components of the tensions? Support your answer.

4. In all of these trials, what must be true about the sum of the horizontal components of the tensions? Support your answer.

5. For each trial, find the components of the tensions in both strings. Show an example of your calculations here, and record all your results in the table.

	Tension T_1		Tension T_2	
Angle	*Horizontal Component*	*Vertical Component*	*Horizontal Component*	*Vertical Component*
90°				
60°				
45°				
30°				

6. How do your calculations compare to your answers to questions 3 and 4?

7. If you hang some wet clothes on a clothesline, why must the clothesline sag? Could it ever be perfectly horizontal?