Name ______________________ Date __________ Class __________

WORKSHEET

48 MATH IN SCIENCE: PHYSICAL SCIENCE

MATH SKILLS USED
Subtraction
Multiplication
Decimals
Scientific Notation

Newton: Force and Motion

Use the equations for acceleration and Newton's second law to learn about the motions and forces in the world around us.

In the seventeenth century, a brilliant young scientist named Isaac Newton explained the relationship between force, mass, and acceleration. This simple relationship describes much of the force and motion in the universe, from a tossed baseball to the motion of the stars and planets.

Part 1: Acceleration

Have you ever seen the start of an auto race? In one instant, the cars are practically motionless. The next instant, they are almost flying around the track. What acceleration! But did you know that as a speeding car slows to turn, it is also accelerating? **Acceleration** is defined as the rate at which the velocity of an object changes. In other words, acceleration is a measure of how quickly something speeds up *or* slows down. The equation for acceleration is given below.

EQUATION: change in velocity = final velocity − initial velocity

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time}}$$

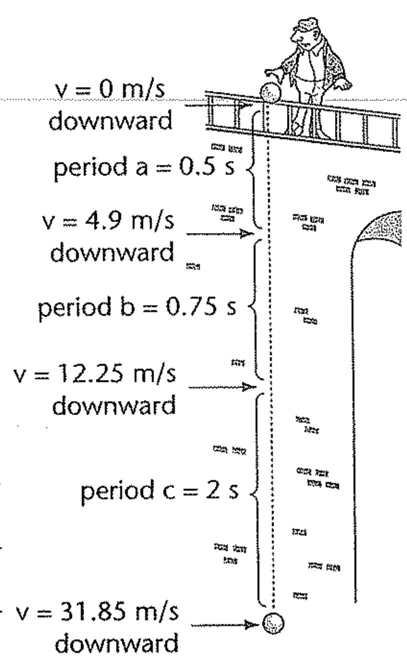
SAMPLE PROBLEM: What is the acceleration of an in-line skater who increases her velocity from 3.5 m/s forward to 6 m/s forward in 2 seconds?

$$\text{change in velocity} = 6\text{ m/s} - 3.5\text{ m/s} = 2.5\text{ m/s}$$

$$\text{acceleration} = \frac{2.5\text{ m/s}}{2\text{ s}}$$

$$\text{acceleration} = \mathbf{1.25\ m/s^2\ forward}$$

1. Calculate the acceleration of the ball for each time period that it falls.



a. ______________________

b. ______________________

c. ______________________

Challenge Yourself!

2. A jet flying at 200 m/s north accelerates at a rate of 18.2 m/s^2 for 15 seconds. What is the jet's final velocity?

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Part 2: Newton's Second Law

Isaac Newton expressed the relationship between force, mass, and acceleration in his second law. This law is so important that it became the basis for much of modern physics. In fact, Newton's contribution to science was so great that the unit for force, the newton (N), was named after him. A newton is defined as the force needed to produce an acceleration of 1 m/s^2 on a 1 kg object. Therefore, $1\ N = 1\ kg \times 1\ m/s^2$. The equation for Newton's second law is given below.

EQUATION:

$$\text{Force} = \text{mass} \times \text{acceleration}$$
$$F = m \times a$$

If you know two of the values in this equation, you can calculate the third by changing the equation around, as follows:

$$\text{acceleration} = \frac{\text{Force}}{\text{mass}} \quad \textit{and} \quad \text{mass} = \frac{\text{Force}}{\text{acceleration}}$$

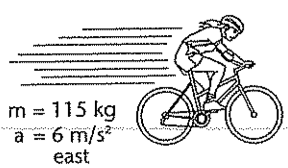
SAMPLE PROBLEM: A soccer ball accelerates at a rate of 22 m/s^2 forward when kicked by a player. The soccer ball has a mass of 0.5 kg. How much force was applied to the ball to produce this acceleration?

$$\text{Force} = \text{mass} \times \text{acceleration}$$
$$\text{Force} = 0.5\ kg \times 22\ m/s^2$$
$$\text{Force} = 11\ kg \times m/s^2$$
$$\text{Force} = \mathbf{11\ N}$$

Use the equations above to complete the following problems:

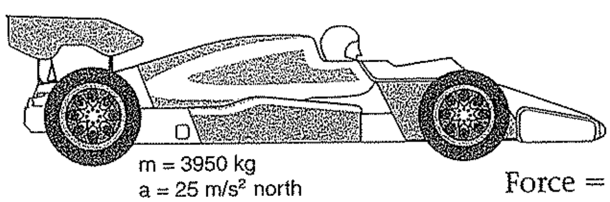
3. Calculate the force necessary to accelerate the following vehicles at the rate of acceleration shown in the illustration.

a.



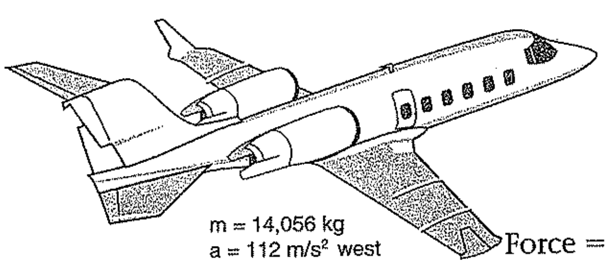
Force = ______________________

b.



Force = ______________________

c.



Force = ______________________

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4. How much force is needed to move a 0.1 kg snowball at a rate of 15 m/s^2 upward?

5. A 0.02 N push accelerates a table-tennis ball along a table at 8 m/s^2 north. What is the mass of the ball?

6. At lift-off, an astronaut on the space shuttle experiences an acceleration of approximately 35 m/s^2 upward. What force does an 80 kg astronaut experience during this acceleration?

7. What is the acceleration of a train with a mass of 3.2×10^9 kg that pushes itself forward with 2.4×10^{10} N of force?

Part 3: The Force of Gravity

Forces are not always exerted on objects by direct physical contact, such as a hand pushing a door closed. For instance, the Earth exerts the force of gravity on objects even when the objects are not directly touching the ground. The acceleration on an object due to the force of gravity is 9.8 m/s^2 downward. In other words, for every second an object is falling, its velocity increases by 9.8 m/s downward.

8. a. A 9 kg bowling ball rolls off a table and strikes the ground. If the ball is in the air for 0.5 seconds, how fast is the ball moving when it hits the ground?

b. Another bowling ball with one-fifth less mass rolls off the same table and strikes the ground. When this ball hits the ground, is it moving faster, slower, or the same speed as the first ball? Explain your answer.