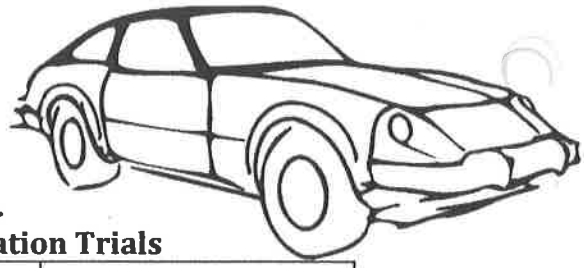
(6)

Name _____ Block _____ Date_____

Newton's Second Law of Motion



Trial 1

GM is designing a new, lighter sports car.
It has a mass of 1,000 kg. They ran 5 trials to see how a change in force would result in a change of acceleration.
Examine the table below to answer the following questions.

$a = \frac{F}{m}$

Data Table 1: GM Force and Acceleration Trials

Trial	Force (N)	Mass (kg)	Acceleration (m/s^2)
1	2,000	1,000	2
2	4,000	1,000	4
3	8,000	1,000	8
4	12,000	1,000	12
5	16,000	1,000	16

A1. What are the units of force? N

A2. What are the units of mass? Kg

A3. What are the units of acceleration? m/s^2

A4. Circle the data for Trial 2 & Trial 3. How many times greater is the force applied in Trial 3 (compared to 2)? 2X How many times greater is the acceleration in Trial 3? 2X

A5. Circle the data for Trial 2 & Trial 4. How big is the force applied in Trial 2 (compared to 4)? 1/3 How big is the acceleration in Trial 2 (compared to 4)? 1/3

A6. For the same object, what is the relationship between acceleration and force? **Circle 1.**

a. A big force causes a big acceleration (direct relationship) F↑ a↑

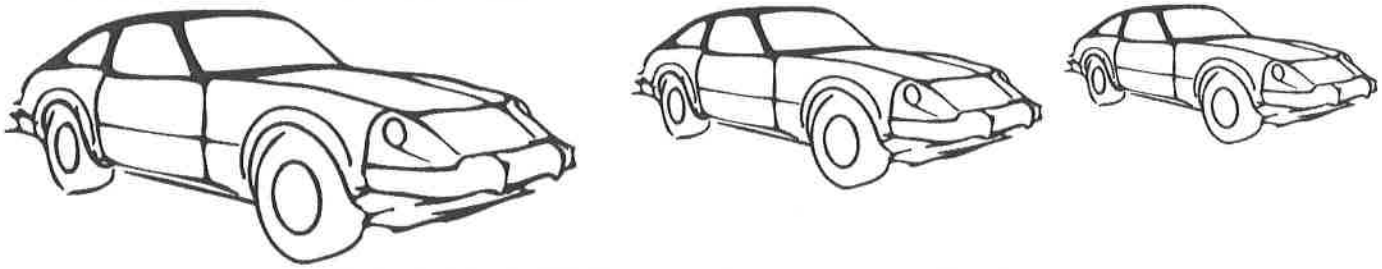
b. A big force causes a small acceleration (~~indirect relationship~~ inverse)

A7. Based on this relationship, fill in the missing data on the table. Explain your answers.

As force increases, acceleration increases.

Trial 2

GM wants to see how the mass of the car affects the force required to accelerate the car by the same amount. A second set of trials are run in order to see how much force is needed to accelerate cars of different masses.



Data Table 2: GM Force and Acceleration Trials

$a = \frac{F}{m}$

Trial	Force (N)	Mass (Kg)	Acceleration (m/s^2)
1	6,000	500	12
2	6,000	1,000	6
3	6,000	2,000	3
4	6,000	3,000	2
5	6,000	4,000	1.5

B1. Label Data Table 2 with the proper units for each quantity.

B2. Circle the data for Trial 2 & Trial 3. How big is the acceleration in Trial 3 (compared to 2)? ½ How many times greater is the mass in Trial 3? 2X

B3. Circle the data for Trial 2 & Trial 4. How much greater is the acceleration in Trial 2 (compared to 4)? 3X How big is the mass in Trial 2 (compared to 4)? ⅓

B4. For the same amount of force, what is the relationship between acceleration and mass?

a. A large mass will have a large acceleration. (direct relationship)

b. A large mass will have a small acceleration. (~~indirect~~ inverse relationship)

B5. Based on this relationship, fill in the missing data on the table. Explain your answers.

As mass increases, acceleration decreases.

C1. To summarize the findings in section A and B, you now know that acceleration is directly related to force and inversely related to mass.

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The conclusion you have just drawn is Newton's second law of motion! **It states that the acceleration of an object depends upon two variables – the force acting on the object and the mass of the object.**

Mathematically this means: $acceleration = \frac{force}{mass}$ (a is directly related to F) (a is indirectly related to m)

If you multiply, both sides of the equation by mass, you will see Newton's second law as it is most commonly written. $a = \frac{F}{m}$ ↙ **$F = ma$** ↘ $m = \frac{F}{a}$

To summarize Newton's second law in simpler language, fill in the following blanks:

C2. A big force causes a big acceleration.

C3. A small force causes a small acceleration.

C4. A massive (heavy) object requires a big force to accelerate it.

C5. A lightweight object only needs a small force to accelerate it.

C6. If you apply the same force to the objects below which will accelerate more? Why?

(*) mA

or

same F

Ma

less mass, less inertia

Let's examine the units used for force, mass, and acceleration in F = ma.

D1. What are the units of force? N mass? Kg acceleration? m/s^2

D2. What units should you get when you multiply mass and acceleration? $Kg\ m/s^2$

D3. Believe it or not, your answer to D2 is equal to a Newton. **$1\ N = \frac{kg\ m}{s^2}$**

D4. Let's try the following problem. What is the acceleration of a 6.4 kilogram bowling ball if a force of 12N is applied to it?

m = 6.4 kg
F = 12 N
a = ?

Let's rearrange F = ma so that a is by itself on the left hand side.

$a = \frac{F}{m} = \frac{12\ N}{6.4 kg} = 1.875\ \frac{N}{kg}$ → Is N/kg the unit of acceleration? yes

We can rewrite N as $\frac{kg\ m}{s^2}$ $= \frac{12\ \cancel{kg}\ m}{6.4\ \cancel{kg}\ s^2} = 1.875\ \frac{m}{s^2}$

$\frac{N}{Kg} = \frac{Kg\frac{m}{s^2}}{Kg}$ but use $\frac{m}{s^2}$

Now you have the correct units for acceleration.
What is your final answer rounded to the right number of sigfigs?

$1.9\ \frac{m}{s^2}$

Exercises

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Use 4-step smooth form to solve.

For the following problems, circle each quantity and label it. Write the formula you will use. Remember to use sig figs and label your answer with units.

1. What is the acceleration of a 2,200-kilogram truck if a force of 4,200N is used to make it start moving forward?

2 s.f. $a = \frac{F}{m} = \frac{4{,}200\text{N}}{2{,}200\text{kg}} = \boxed{1.9\ \frac{\text{m}}{\text{s}^2}}$

$F = 4{,}200\text{N}$
$m = 2{,}200\text{kg}$
$a = ?$

2. What is the acceleration of a 0.30kilogram ball that is hit with a force of 25N?

2 s.f. $a = \frac{F}{m} = \frac{25\text{N}}{0.30\text{kg}} = \boxed{83\ \frac{\text{m}}{\text{s}^2}}$

$F = 25\text{N}$
$m = 0.30\text{kg}$
$a = ?$

3. How much force is needed to accelerate a 68kilogram-skier at 1.2m/s²?

2 s.f. $F = ma = 68\text{kg}\left(1.2\ \frac{\text{m}}{\text{s}^2}\right) = \boxed{82\text{N}}$

$m = 68\text{kg}$
$a = 1.2\text{m/s}^2$
$F = ?$

4. What is the mass of an object that requires a force of 30N to accelerate at 5m/s²?

1 s.f. $m = \frac{F}{a} = \frac{30\text{N}}{5\ \frac{\text{m}}{\text{s}^2}} = \boxed{6\text{kg}}$

$F = 30\text{N}$
$a = 5\text{m/s}^2$
$m = ?$

5. What is the mass of an object that needs a force of 4,500 N to accelerate it at a rate of 5 m/s²?

1 s.f. $m = \frac{F}{a} = \frac{4500\text{N}}{5\text{m/s}^2} = \boxed{900\text{kg}}$

$F = 4{,}500\text{N}$
$a = 5\text{m/s}^2$
$m = ?$