1. A red box and a blue box move along the floor with the same acceleration. The force on the red box is five times larger than on the box. The masses are related as

\[ M_{\text{blue}} = 5 \times M_{\text{red}} \]

\[ M_{\text{red}} = 5 \times M_{\text{blue}} \]

\[ M_{\text{red}} = 25 \times M_{\text{blue}} \]

Since \( F = ma \), if the force is 5 times bigger, the mass must be 5 times bigger to give the same acceleration.

Chap. 4

2. A bullet with mass 0.01 kg leaves the end of a rifle of with a velocity of 1000 m/s 0.002 s after being fired. Assuming constant acceleration of the bullet, find the force with which the rifle kicks your shoulder.

The acceleration of the bullet is

\[ 1000 \text{ m/s} / 0.002 \text{ s} = 500,000 \text{ m/s/s} \]

The force on the bullet is

\[ F = ma = (0.01 \text{ kg}) \times (500,000 \text{ m/s/s}) = 5000 \text{ N} \]

There must be an equal force of 5000 N in the opposite direction kicking your shoulder.

Chap. 4
3. An object of mass 1 kg is moving at a constant velocity of 10 m/s. The net force on the object is

\[ 1 \text{ N} \]
\[ 10 \text{ N} \]
\[ 0 \text{ N} \]
\[ 0.1 \text{ N} \]

*Constant velocity means that the acceleration is zero. From \( F = ma \), zero acceleration means zero net force.*

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**Chap. 4**

4. A middle aged physics professor who gets no exercise and a weight-lifting college student sit in roller chairs and push off from each other as hard as they

Which has greater force applied to him?

- Student
- Professor

*These are a force pair, and so must be equal and opposite. In fact, if the student and professor have the same mass, they will even accelerate at the same rate in opposite directions.*

**Equal**

Demonstrations are boring

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**Chap. 4**
5. A book is at rest on a table. How many forces are acting on it?

0 forces
The force of gravity is acting downward on the book. Since the book is not accelerating, there must be an upward force on the book (from the table) that cancels the gravitational force. There are two forces acting on the book, although the net force is zero.

1 force

2 forces

3 forces

Chap. 4

6. Two people on roller chairs have masses of 50 kg and 100 kg. They push off each other so that the 50 kg person accelerates at 1 m/s². The 100 kg person accelerates in the opposite direction at

0.5 m/s²
These are force pairs, so the must be equal and opposite. Since the 100 kg person has twice the mass, she must accelerate at half the rate, or 0.5 m/s/s.

1 m/s²

2 m/s²

10 m/s²

Chap. 4
7. A bobsled team pushes their sled with a constant force of 100 N. To be competitive, they need to increase their 2 m/s² acceleration to 2.5 m/s². They can do this by reducing the sled mass by

- 5 kg
- 10 kg
- 20 kg

From \( m = \frac{F}{a} \), the sled mass must be 100 N/2 m/s/s = 50 kg. To accelerate at 2.5 m/s/s using 100 N, the sled mass must be \( m = \frac{F}{a} = 100 \text{ N} / 2.5 \text{ m/s/s} = 40 \text{ kg} \). So the mass of the sled must be reduced by 10 kg.

Not enough information to do the problem.

Chap. 4

8. I weigh 220 lbs. What is my weight in kg?

- 200 kg
- 100 kg
- 50 kg

Impossible to determine

**kg** is a unit of mass not weight. Weight is the force of gravity on an object and has units of newtons. Weight cannot be expressed in kg.

Chap. 4
9. I throw a ball of weight 10 N directly upward with a force of +20 N (up is positive). After the ball leaves my hand, the net force on the ball as it moves upward (neglecting air resistance) is

20 N up
10 N up
0 N
10 N down

After the ball leaves my hand, the only force on the ball is the force of gravity. Since the weight is the force of gravity on the ball, the force is 10 N down. This means the ball is decelerating in its upward motion. This makes sense because the speed of the ball upward will eventually decrease to zero as it reaches its maximum height and begins falling.

Chap. 4

10. A 100 kg astronaut is stranded in space with two airtanks lasting 1 hr each. If she removes one tank and throws it by applying a force of 100 N over 1 second, how far will she travel on the 1 remaining hour of air?

Over the 1 second period, there is a reactive force on the astronaut of 100 N, producing an acceleration of $a = F/m = 100 N/100 \text{ kg} = 1 \text{ m/s/s}$. Her velocity after the 1 second of acceleration is $(1 \text{ m/s/s}) \times (1\text{s}) = 1 \text{ m/s}$. Since 1 hr is 3600 s, she will travel $(1 \text{ m/s}) \times (3600 \text{ s}) = 3600 \text{ m}$.
11. A 1 kg mass on earth weighs about 10 N. What are its mass and weight in outer space?

| Mass 0 | Weight is the force of gravity on an object. There is negligible force from gravity in outer space, so the weight is zero. The mass of an object is a property of the object, related to how many and what kind of atoms make it up. It does not change. Mass 1 kg, weight 0 N |
| Mass 1 kg, weight 10 N |
| Mass 0 kg, weight 10 N |

Chap. 4