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Forces and the Laws of Motion

Problem C

NEWTON'S SECOND LAW

PROBLEM

Two students reach for a jar of mustard at the same time. One student pulls to the left with a force of 13.2 N, while the other student pulls to the right with a force of 12.9 N. If the jar has a net acceleration of 0.44 m/s^2 to the left, what is the mass of the jar?

SOLUTION

Given: $\mathbf{F_1} = 13.2$ N to the left

$\mathbf{F_2} = 12.9$ N to the right

$\mathbf{a_{net}} = 0.44$ m/s^2 to the left

Unknown: $m = ?$

Use Newton's second law and solve for m.

$$\Sigma \mathbf{F} = m\,\mathbf{a} = m\,\mathbf{a_{net}}$$

$$\Sigma \mathbf{F} = \mathbf{F_1} + \mathbf{F_2} = F_1 - F_2 \text{ to the left}$$

$$F_1 - F_2 = 13.2 \text{ N} - 12.9 \text{ N} = 0.30 \text{ N}$$

$$m = \frac{\Sigma F}{a_{net}} = \frac{0.30 \text{ N}}{0.44 \text{ m/s}^2}$$

$$m = \boxed{0.68 \text{ kg}}$$

ADDITIONAL PRACTICE

1. A house is lifted from its foundations onto a truck for relocation. The house is pulled upward by a **net** force of 2850 N. This force causes the house to move from rest to an upward speed of 15 cm/s in 5.0 s. What is the mass of the house? 9.5×10^4 kg

2. Suppose an empty grocery cart rolls downhill in a parking lot. The cart undergoes a constant increase in speed of 1.0 m/s over a 5.0 s interval. If the downhill force acting on the cart is 18.0 N and the uphill force due to friction is 15.0 N, what is the cart's mass? 15 kg

3. A certain cable of an elevator is designed to exert a force of 4.5×10^4 N. If the maximum acceleration that a loaded car can withstand is 3.5 m/s^2 (the current fastest elevators in the world undergo an acceleration of less than 3.2 m/s^2), what is the combined mass of the car and its contents? 3.4×10^3 kg

4. An 2.0-kg fish pulled upward by a fisherman rises 1.9 m in 2.4 s, starting from rest. Assuming the acceleration is constant, find the magnitude and direction of the net force acting on the fish during this interval. 1.3 N up

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5. An 8.0-kg bag of coins is being pulled upward by a rope rises 20.0 cm in 0.50 s, starting from rest. Assuming the acceleration is constant, calculate the net force on the bag. What is the upward force on the bag exerted by the rope?

13N up
91N up

6. A pedestrian with a mass of 75 kg accelerates at 0.15 m/s^2 to the west. A high wind comes up, blowing toward the east. The wind is capable of giving the pedestrian an acceleration of 2×10^{-2} m/s^2. What are the magnitude and direction of the net force acting on the pedestrian?

9.8N W

7. Assume that a catcher in a professional baseball game exerts a force of −65.0 N to stop the ball. If the baseball has a mass of 0.145 kg, what is its net acceleration as it is being caught?

-448 m/s^2

8. A 214 kg boat is sinking in the ocean. The boat's weight is partially offset by the 790 N buoyant force of the water. What is the net acceleration of the boat?

-6.12 m/s^2

9. The Goliath beetle, which is found in Africa, can reach a mass of 0.080 kg. Suppose a Goliath beetle is placed on a slope that makes an angle of 37.0° with the horizontal. Find the acceleration of the beetle along the slope, assuming the slope to be frictionless.

5.9 m/s^2 down

10. If an force of 1.40 N upward along the slope is applied to the beetle in problem 9, what is the beetle's acceleration?

12 m/s^2

Problem C

1) $F_{net} = 2850N$
$V_i = 0 cm/s$
$V_f = 15 cm/s = .15 m/s$
$t = 5s$

$$\frac{V_f - V_i}{t} = a$$

$$\frac{.15 - 0}{5} = .03 \, m/s^2$$

$F_{net} = ma$
$2850N = x(.03)$
$95000 kg = x$

2) $V_f = 1.0 m/s$
$V_i = 0$
$t = 5s$
$F_{Net} = 18 - 15 = 3N$

$$\frac{V_f - V_i}{t} = a = \frac{1 - 0}{5} = .2 \, m/s^2$$

$F_{Net} = ma$
$3 = x(.2)$
$x = 15 kg$

3) $4.5 \times 10^4 N = F$
$a = 3.5 m/s^2 + 9.81 m/s^2 = 13.31$

$$\frac{4.5 \times 10^4}{13.31} = 3381 \, kg$$

4) $m = 2 kg$
$d = 1.9$
$t = 2.4$
$V_i = 0$
$a = ?$

$$d = \cancel{V_i t}^{0} + \tfrac{1}{2} a t^2$$

$$a = \frac{2d}{t^2} = \frac{2(1.9)}{2.4^2} = \frac{3.8}{5.76} = .66 \, m/s^2$$

$F = m(a)$
$x = 2(.66) = 1.3 N \, up$

5) $m = 8 kg$
$d = .20 m$
$t = .5s$
$V_i = 0$

a) $$d = \frac{2d}{t^2} = \frac{2(.2)}{.5^2} = 1.6 \, m/s^2 \times 8 = 12.8 N up$$

b) $1.6 + 9.81 = 11.41 m/s^2 \times 8 = 91.28 N up$