

Net Forces

1. A rubber ball weighs 49 N.

a. What is the mass of the ball?

$$W = mg$$

$$49 \text{ N} = m \cdot 9.8 \frac{\text{m}}{\text{s}^2}$$

$$m = 5 \text{ kg}$$

b. What is the acceleration of the ball if an upward force of 69 N is applied?

$$F_{\text{NET}} = F_U - F_D$$

$$= 69 \text{ N} - 49 \text{ N} = 20 \text{ N}$$

$$F_{\text{NET}} = ma$$

$$20 \text{ N} = 5 \text{ kg } a$$

$$a = 4 \frac{\text{m}}{\text{s}^2}$$

2. A small weather rocket weighs 14.7 N.

a. What is its mass?

$$W = mg$$

$$14.7 \text{ N} = m \cdot 9.8 \frac{\text{m}}{\text{s}^2}$$

$$m = 1.5 \text{ kg}$$

b. The rocket is carried up by a balloon. The rocket is released from the balloon and fired, but its engine exerts an upward force of 10.2 N. What is the acceleration of the rocket?

$$F_{\text{NET}} = ma$$

$$-4.5 \text{ N} = 1.5 a$$

$$a = -3 \frac{\text{m}}{\text{s}^2}$$

$$F_{\text{NET}} = 10.2 \text{ N} - 14.7 \text{ N}$$

$$F_{\text{NET}} = -4.5 \text{ N}$$

3. The space shuttle has a mass of $2 \times 10^6 \text{ kg}$. At lift-off the engines generate an upward force of $30 \times 10^6 \text{ N}$.

a. What is the weight of the shuttle?

$$W = mg$$

$$= 2 \times 10^6 \text{ kg} \cdot 9.8 \frac{\text{m}}{\text{s}^2} = 1.96 \times 10^7 \text{ N}$$

b. What is the acceleration of the shuttle when launched?

$$F_{\text{NET}} = F_U - F_D$$

$$= 30 \times 10^6 \text{ N} - 1.96 \times 10^7 \text{ N} = 1.04 \times 10^7 \text{ N}$$

$$F_{\text{NET}} = ma$$

$$1.04 \times 10^7 \text{ N} = 2 \times 10^6 \text{ kg } a$$

$$a = 5.2 \frac{\text{m}}{\text{s}^2}$$

c. The average acceleration of the shuttle during its 10 minute launch is 13 m/s^2 . What velocity does it attain?

$$t = 10 \text{ min} \cdot \frac{60 \text{ s}}{1 \text{ min}}$$

$$a = \frac{v_f - v_i}{t} = 13 \frac{\text{m}}{\text{s}^2} = \frac{v_f - 0}{600 \text{ s}}$$

$$v_f = 7.8 \times 10^3 \frac{\text{m}}{\text{s}}$$

4. A sports car accelerates from 0 to 60 mph in 9 s (average acceleration = 3 m/s^2).

The mass of the car is 1354 kg. The average backward force due to air drag during acceleration is 280 N. Find the forward force required to give the car this acceleration.

$$F_{\text{NET}} = ma$$

$$= 1354 \text{ kg} \cdot 3 \frac{\text{m}}{\text{s}^2}$$

$$F_{\text{NET}} = 4062 \text{ N}$$

$$F_{\text{NET}} = F_m - F_R$$

$$4062 \text{ N} = F_m - 280 \text{ N}$$

$$F_m = 4.34 \times 10^3 \text{ N}$$

$$-2.55 \times 10^3 \text{ N}$$

5. A force of -9000 N is used to stop a 1500 kg car traveling at 20 m/s. What braking distance is needed to bring the car to a halt?

$$F_D = ma$$

$$-9000 \text{ N} = 1500 \text{ kg } a$$

$$a = -6 \frac{\text{m}}{\text{s}^2}$$

$$v^2 = v_i^2 + 2ad$$

$$0 = (20 \frac{\text{m}}{\text{s}})^2 + 2(-6 \frac{\text{m}}{\text{s}^2})d$$

$$d = 3.33 \times 10^1 \text{ m}$$

6. A 65 kg swimmer jumps off a 10 m tower.

a. Find the swimmer's velocity when hitting the water.
 b. The swimmer comes to a stop 2 m below the surface. Find the net force exerted by the water.

$$d = v_i t + \frac{1}{2} g t^2$$

$$10 \text{ m} = 0 + \frac{1}{2} (9.8 \frac{\text{m}}{\text{s}^2}) t^2$$

$$t = 1.43 \text{ s}$$

$$v = v_i + a t$$

$$= 0 + (9.8 \frac{\text{m}}{\text{s}^2}) 1.43 \text{ s} = 1.40 \times 10^1 \frac{\text{m}}{\text{s}}$$

$$v^2 = v_i^2 + 2ad$$

$$0 = (14 \frac{\text{m}}{\text{s}})^2 + 2a(2 \text{ m})$$

$$a = -49 \frac{\text{m}}{\text{s}^2}$$

$$F_{\text{NET}} = ma$$

$$= 65 \text{ kg} \cdot 49 \frac{\text{m}}{\text{s}^2}$$

$$= -3.19 \times 10^3 \text{ N}$$

$$F_D = mg = 65 \cdot 9.8 \frac{\text{m}}{\text{s}^2} = 637 \text{ N}$$

$$F_{\text{NET}} = F_U - F_D$$

$$-3.19 \times 10^3 \text{ N} = F_U - 637 \text{ N}$$

