Apparent Weight

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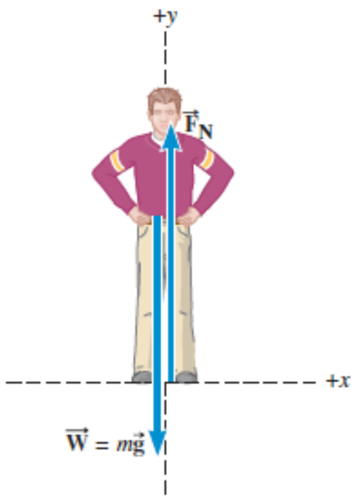
P3.4B Identify forces acting on objects moving with constant velocity (e.g., cars on a highway).
P3.4C Solve problems involving force, mass, and acceleration in linear motion (Newton's second law).

Free-Body Diagrams

A free-body diagram is a diagram showing all external forces acting on the object. It has a coordinate system (Y, X). It is used to solve problems involving forces.

Below is a free-body diagram showing the forces acting on the person standing on a scale. Y and X are the coordinate system. Two forces are present W and F_N



W is the true weight.

F_N is the normal force (or support forces) exerted by the platform of the scale, on the person.

Apparent Weight

When we are in an elevator accelerating upward ($a > 0$), we feel heavier.
When the elevator accelerates downward ($a < 0$), we feel lighter.
When the elevator is in free fall, we feel Weightless as if we are at the moon.

There are situations in which the scale not give the "True Weight". In a moving elevator, the reading on the scale reads gives what we call the "Apparent Weight".

When applying Newton's Second Law of Motion:

$$\text{Sum of the forces along the y axis} = F_N - W = m \times a$$

$$F_N - m \times g = m \times a, \qquad \text{therefore,} \qquad F_N = m \times g + m \times a$$

Apparent Weight = True Weight + m x a

<u>Explanation:</u>

I. When the elevator is not accelerating ($a = 0$). Then, $m \times a = 0$. So, our apparent weight is equal to our true weight. The scale will read our weight.

Apparent Weight = True Weight

II. When the elevator accelerates upward with uniform acceleration ($a > 0$). Then, $m \times a > 0$. So, our apparent weight (F_N) is more than our true weight. The reading on the scale reads the apparent weight, which is more than our true weight.

Apparent Weight = True Weight + m x a > True Weight

III. When the elevator accelerate downward with uniform acceleration ($a < 0$). Then, $m \times a < 0$. So, our apparent weight is less that our true weight. The reading on the scale reads the apparent weight, which is less than our true weight.

$$\text{Apparent Weight} = \text{True Weight} - m \times a < \text{True Weight}$$

IV. If the elevator is in free fall, the downward acceleration is $a = -g$. Therefore, our apparent weight is 0. Thus the person feels weightless in a freely falling elevator.

$$\text{Apparent Weight} = m\,(g + a) = m\,(g - g) = 0$$

$\boldsymbol{g = 9.8}$ **m/s²** : Acceleration due to the gravity of the earth.

Practice Problem: Answer questions 1 and 2.

1. A person of true weight of 700 N is standing on a platform of a scale inside an elevator. as shown in the four pictures below:

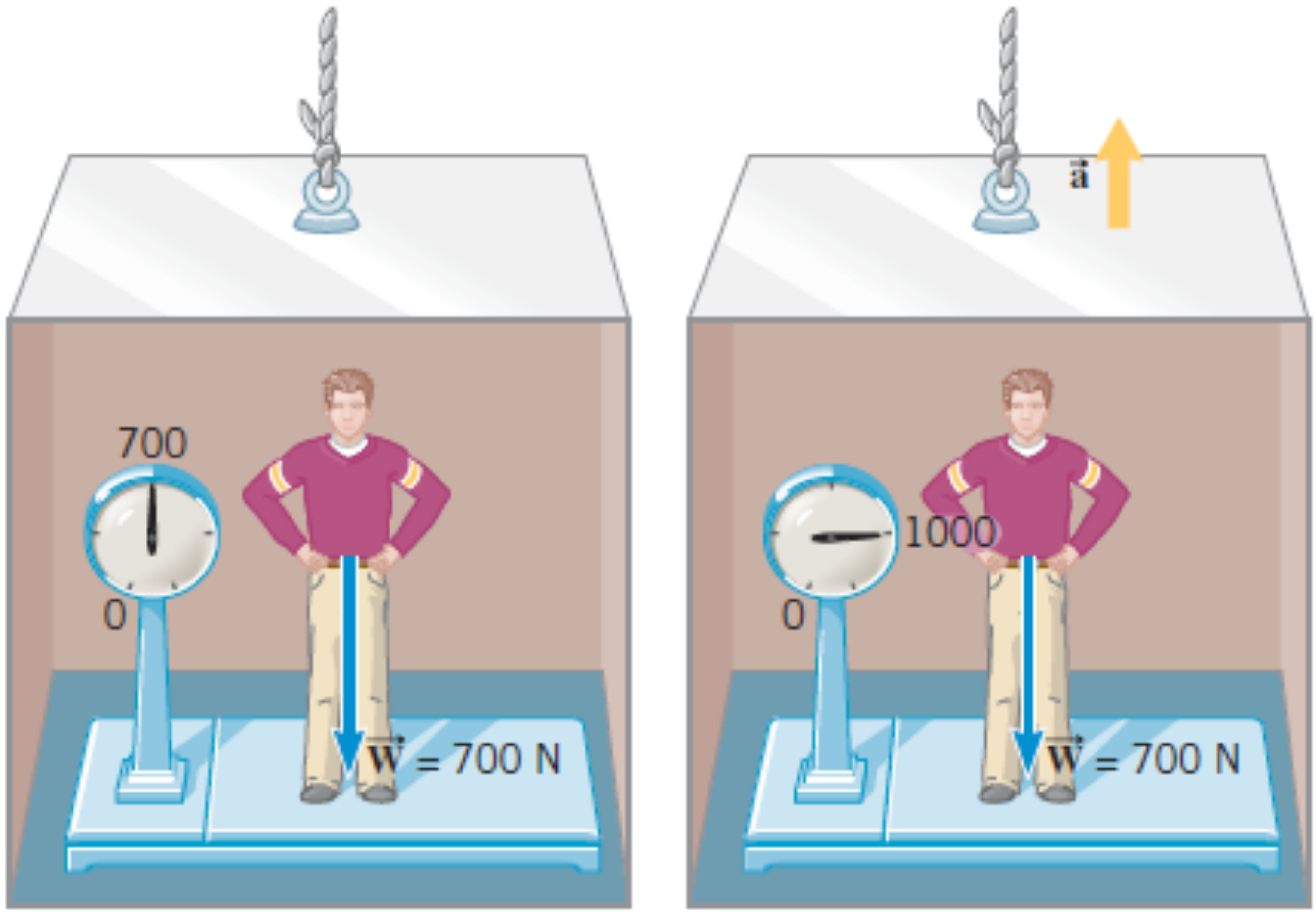
a) The elevator is not accelerating

b) The elevator is accelerating upward

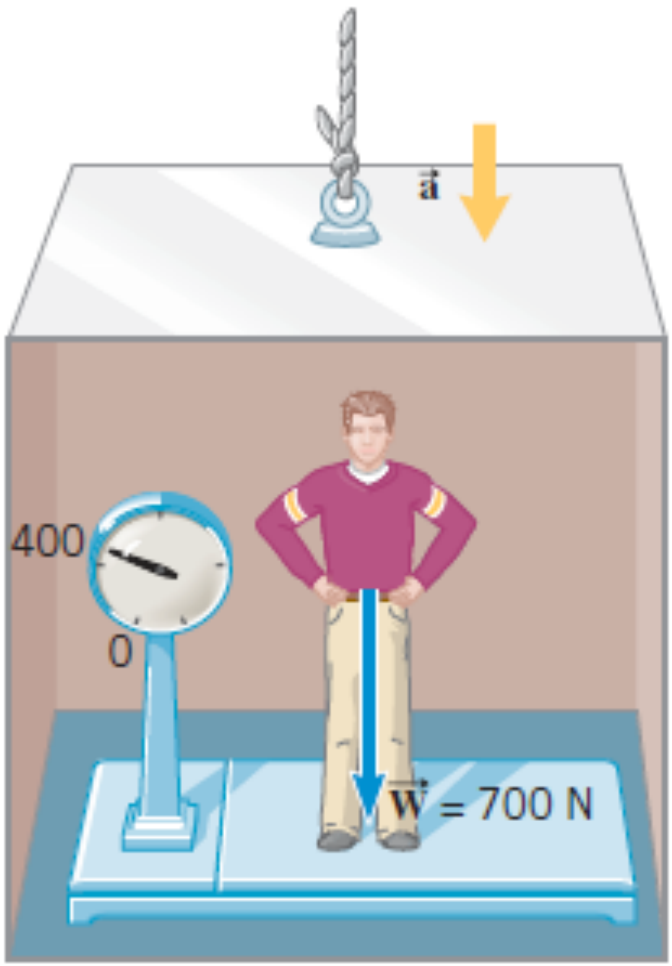
c) The elevator is accelerating downward

d) The rope is broken and the elevator is in free fall.

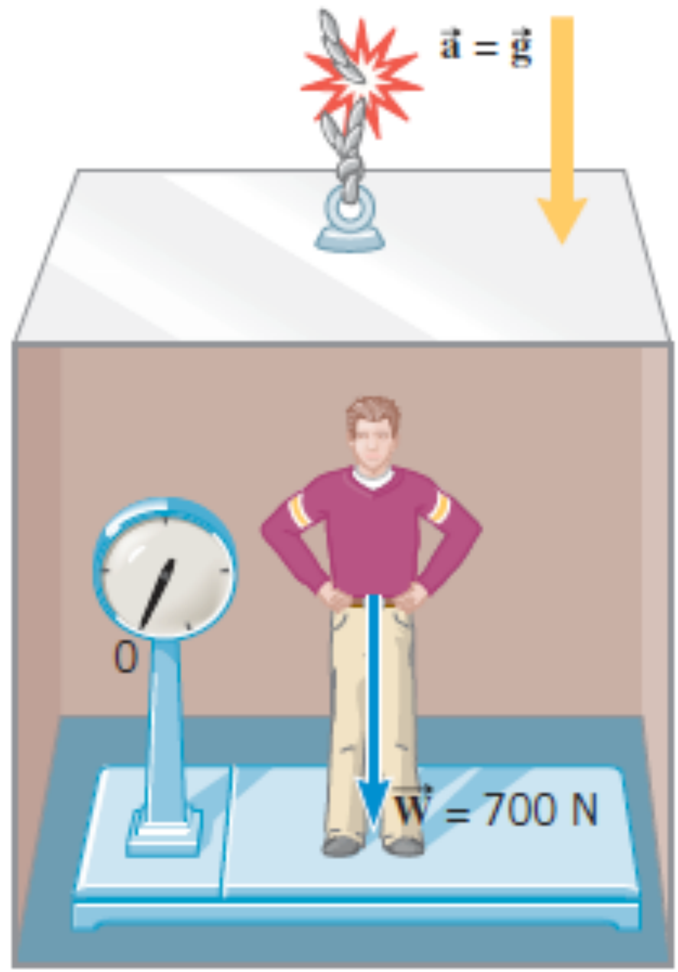
Use the explanation above to explain the **reading of the scale** in each picture.



(*a*) No acceleration ($\vec{v}$ = constant)   (*b*) Upward acceleration



(*c*) Downward acceleration



(*d*) Free-fall

2. Astronauts are trained and gain experience on weightlessness on Earth before they are sent in shuttle to space. What are some of the procedures used on Earth for the astronaut to feel weightless and practice their duties before they are launched to space?