Apparent Weight

by

Nada Saab-Ismail, PhD, MAT, MEd, IB

nhsaab.weebly.com

nhsaab2014@gmail.com

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).

Apparent Weight

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

The apparent weight of an object is the reading of the scale. It is equal to the normal force the scale exerts on the man.

When we are in an elevator accelerating upward ($a > 0$), we feel heavier.

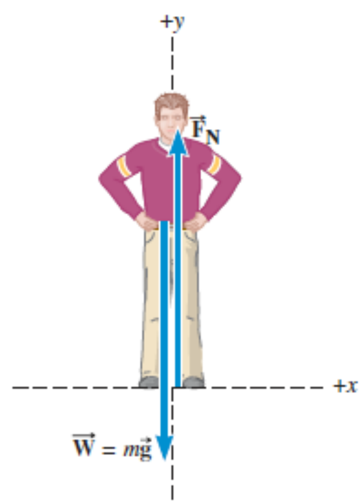
When the elevator accelerates downward ($a < 0$), we feel lighter.

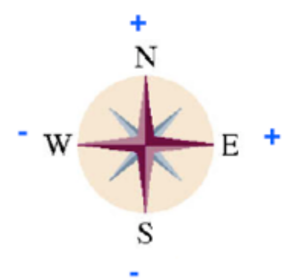
When the elevator is in free fall, we feel Weightless as if we are at the moon.

Free-Body Diagrams of a Person Standing on a Scale

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 systems. Two forces are present W and F_N

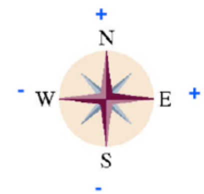




W is the true weight directed toward the center of the Earth: W = mg.

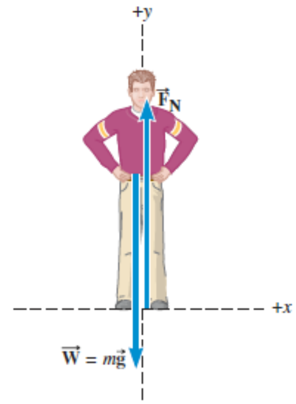
F_N is the normal force (or support forces) exerted by the platform of the scale, on the person and is directed upward. It is the apparent weight.

We can apply Newton's Second Law of Motion:



Net Force = Mass x Acceleration

F net = m x a



Sum of the forces along the y axis (F net) = $F_N - W = m \times a$

$$F_N = W + m \times a$$

Apparent Weight (F_N) = True Weight + (m x a)

$$F_N = (m \times g) + (m \times a)$$

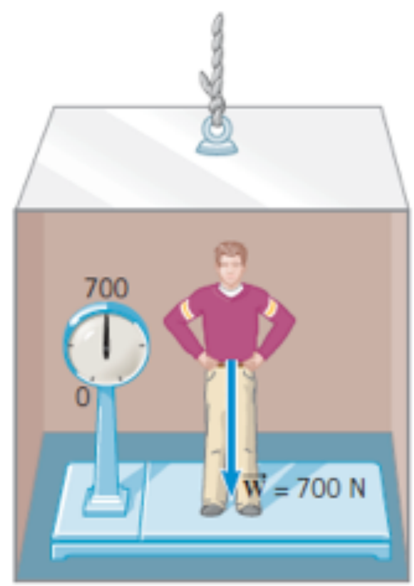
we can derive the acceleration a:

Acceleration: $a = (F_N - m\,g) / m$

Example 1: *A person standing on a scale.*

(a) When the elevator is not accelerating (a = 0). Then, m x a = 0. So, the apparent weight is equal to the true weight. The scale will read the apparent weight which is in the case the true weight.

$$\text{Apparent Weight} = \text{True Weight} = 700 \text{ N}$$



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

We can calculate the mass of the person:

$$\text{Apparent Weight} = \text{True Weight}$$

$$F_N = m \times g$$

$$700 = m \times 9.8$$

So

$$m = 700 / 9.8$$

$$= 71.4 \text{ Kg}$$

We can calculate the acceleration:

$$a = (F_N - m\, g) / m$$

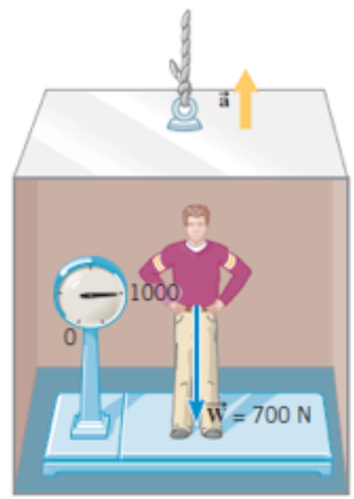
$$= 700 - 700 / 71.4$$

$$= 0 \text{ m/s}^2$$

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

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

$$\text{Apparent Weight} = \text{True Weight} + (m \times a) > \text{True Weight}$$



(b) Upward acceleration

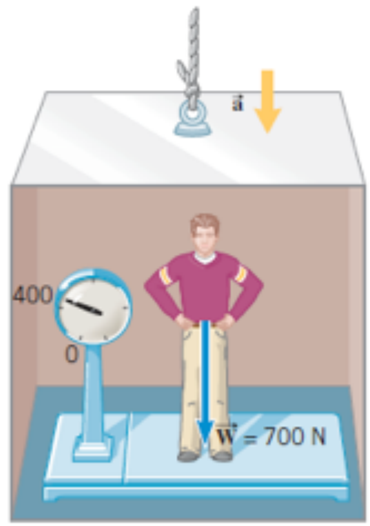
Apparent weight is the reading of the scale: 1000 N. The true weight is 700 N.

We can calculate the acceleration:

$$a = (1000 - 700) / m$$
$$= 300 / 71.4 = 4.20 \text{ m/s}^2$$

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

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



(c) Downward acceleration

Apparent weight is the reading of the scale: 400 N. The true weight is 700 N.

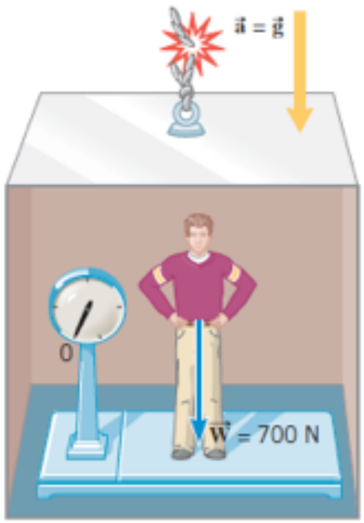
We can calculate the acceleration:

$$a = (400 - 700) / m$$

$$= -300 / 71.4 = -4.20 \text{ m/s}^2$$

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

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



(d) Free-fall

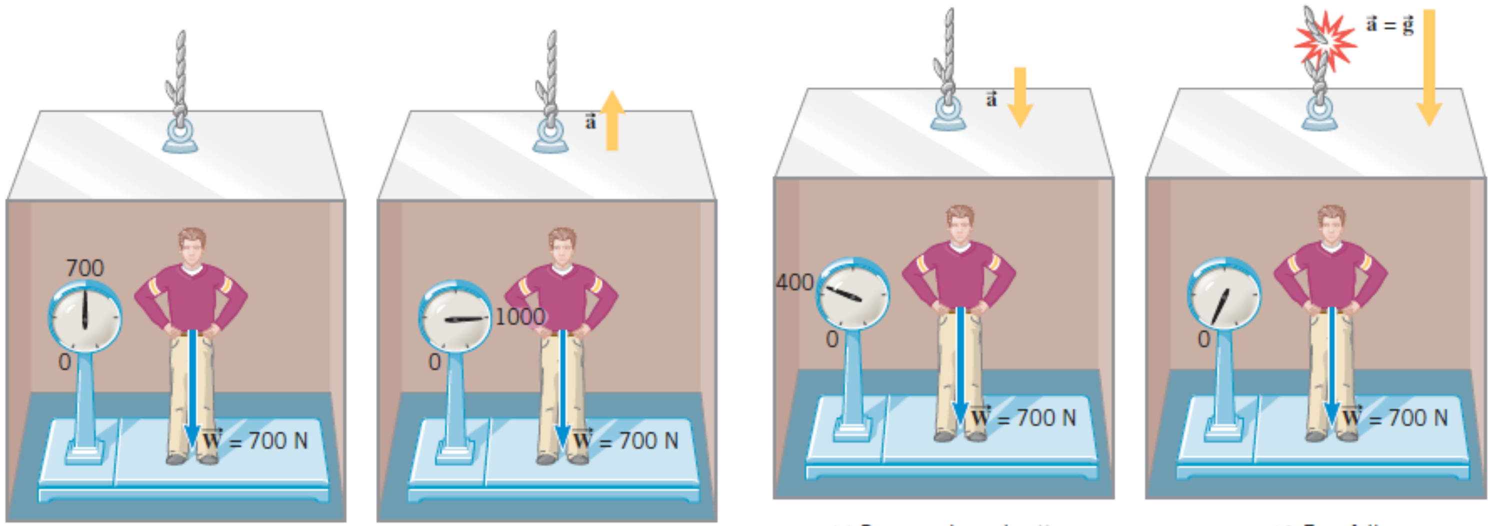
Apparent weight is the reading of the scale: 0 N. The true weight is 700 N.

We can calculate the acceleration:

$$a = (0 - 700) / m$$

$$= - 700 / 71.4 = -9.80 \text{ m/s}^2$$

Summary;



(*a*) No acceleration ($\vec{v}$ = constant) (*b*) Upward acceleration (*c*) Downward acceleration (*d*) Free-fall

References:

1) Humanic. (2013). www.physics.ohio-state.edu/~humanic/. In Thomas Humanic Brochure Page.

Physics 1200 Lecture Slides: Dr. Thomas Humanic, Professor of Physics, Ohio State University, *2013-2014 and Current*. *www.physics.ohio-state.edu/~humanic/*

2) Cutnell, J. D. & Johnson, K. W. (1998). *Cutnell & Johnson Physics, Fourth Edition*. New York: John Wiley & Sons, Inc.

The edition was dedicated to the memory of Stella Kupferberg, Director of the Photo Department:"We miss you, Stella, and shall always remember that a well-chosen photograph should speak for itself, without the need for a lengthy explanation"

3) Martindale, D. G. & Heath, R. W. & Konrad, W. W. & Macnaughton, R. R. & Carle, M. A. (1992). *Heath Physics.* Lexington: D.C. Heath and Company

4) Zitzewitz, P. W. (1999). *Glencoe Physics Principles and Problems*. New York: McGraw-Hill Companies, Inc.

5) Nada H. Saab (Saab-Ismail), (2010-2013) Westwood Cyber High School, Physics.

6) Nada H. Saab (Saab-Ismail), (2009- 2014) Wayne RESA, Bilingual Department.