مراجعة درس Motion and Forces منهج انسباير

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Lesson 2: Force and Motion

Property	Mass	Weight
Definition	The amount of matter in an object.	The gravitational force acting on an object.
Symbol	**m**	**W or F_g**
Formula	**No formula**	**W = m·g**
Nature	Scalar quantity	Vector quantity
Unit (SI)	Kilogram (kg)	Newton (N)
Depends On	The object itself; does not change with location.	Gravitational field strength (g) and mass (m).
Measured By	Balance (e.g., a beam balance).	Spring scale or a force-measuring device.
Variation	Constant, irrespective of location.	Changes with the gravitational field strength.
Gravitational Effect	Independent of gravity.	Directly dependent on gravity.
Example	A person has a mass of 70 kg everywhere.	A person weighing 686 N on Earth would weigh less on the Moon.

What is the weight of an object?

A) The mass of the object multiplied by the acceleration due to gravity.

B) The amount of matter contained in the object.

C) The upward force exerted by a scale.

D) The gravitational field strength of Earth.

If an object has a mass of 10 kg, what is its weight on Earth?

A) 10 N

B) 98 N

C) 9.8 N

D) 100 N

How would the reading on a scale change if measured on a planet with a gravitational field strength of 5 N/kg?

A) The weight would be higher than on Earth.

B) The weight would be the same as on Earth.

C) The weight would be lower than on Earth.

D) The weight would depend on the mass of the scale.

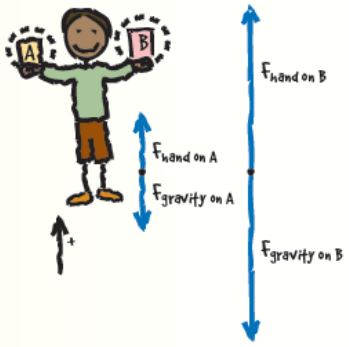
EXAMPLE PROBLEM 2

Find help with operations with significant digits. Math Handbook

COMPARING WEIGHTS Kiran holds a brass cylinder in each hand. Cylinder A has a mass of 100.0 g and cylinder B has a mass of 300.0 g. What upward forces do his two hands exert to keep the cylinders at rest? If he then drops the two, with what acceleration do they fall? (Ignore air resistance.)

1 ANALYZE AND SKETCH THE PROBLEM

- Sketch the situation.
- Identify the two cylinders as the systems, and choose the upward direction as positive.
- Draw the free-body diagrams. Label the forces.



KNOWN	UNKNOWNS
$m_A = 0.1000\ kg$	$F_{Hand\ on\ A} = ?$
$m_B = 0.3000\ kg$	$F_{Hand\ on\ B} = ?$
$g = -9.8\ N/kg$	$a_A = ?\quad a_B = ?$

2 SOLVE FOR THE UNKNOWNS

For cylinder A:

$$F_{Net\ on\ A} = F_{Hand\ on\ A} + F_{Gravity\ on\ A}$$
$$0 = F_{Hand\ on\ A} + F_{Gravity\ on\ A}$$
$$F_{Hand\ on\ A} = -F_{Gravity\ on\ A}$$
$$F_{Hand\ on\ A} = -m_A g$$
$$= -(0.1000\ kg)(-9.8\ N/kg)$$
$$= 0.98\ N\ up$$

For cylinder B:

$$F_{Net\ on\ B} = F_{Hand\ on\ B} + F_{Gravity\ on\ B}$$
$$0 = F_{Hand\ on\ B} + F_{Gravity\ on\ B}$$
$$F_{Hand\ on\ B} = -F_{Gravity\ on\ B}$$
$$F_{Hand\ on\ B} = -m_B g$$
$$= -(0.3000\ kg)(-9.8\ N/kg)$$
$$= 2.9\ N\ up$$

After the cylinders are dropped, the only force on each is the force of gravity. Use Newton's second law.

$$a_A = \frac{F_{Net\ on\ A}}{m_A} \qquad a_B = \frac{F_{Net\ on\ B}}{m_B}$$
$$a_A = \frac{m_A g}{m_A} = g \qquad a_B = \frac{m_B g}{m_B} = g$$

◀ Substitute $F_{Net\ on\ A} = m_A g$ and $F_{Net\ on\ B} = m_B g$.

$$= -9.8\ m/s^2 \qquad = -9.8\ m/s^2$$

◀ Substitute $g = -9.8\ N/kg = -9.8\ m/s^2$.

16. You place a 4.0-kg watermelon on a spring scale that measures in newtons. What is the scale's reading?

The scale reads the weight of the watermelon:
$F_g = mg = (4.0\text{ kg})(9.8\text{ N/kg}) = 39\text{ N}$

17. You place a 22.50-kg television on a spring scale. If the scale reads 235.2 N, what is the gravitational field?

$$F_g = mg$$

$$g = \frac{F_g}{m}$$

$$= \frac{235.2\text{ N}}{22.50\text{ kg}}$$

$$= 10.5\text{ N/kg}$$

18. A 0.50-kg guinea pig is lifted up from the ground. What is the smallest force needed to lift it? Describe the particular motion resulting from this minimum force.

$$F_{lift} = F_g$$

$$= mg$$

$$= (0.50\text{ kg})(9.8\text{ N/kg})$$

$$= 4.9\text{ N}$$

It would move at a constant speed.

19. CHALLENGE A grocery sack can withstand a maximum of 230 N before it rips. Will a bag holding 15 kg of groceries that is lifted from the checkout counter at an acceleration of 7.0 m/s^2 hold?

Use Newton's second law $F_{net} = ma$.

If $F_{bag\ on\ groceries} > 230$ N, then the bag rips.

$$F_{net} = F_{bag\ on\ groceries} + F_g$$

$$F_{bag\ on\ groceries} = F_{net} - F_g$$

$$= (15\text{ kg})(7.0\text{ m/s}^2)$$

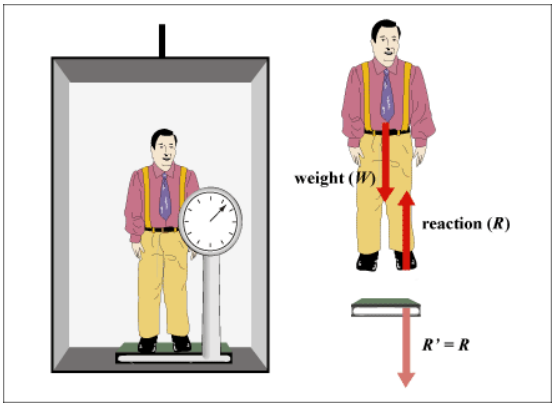
$$- (15\text{ kg})(-9.8\text{ N/kg})$$

$$= 105\text{ N} + 147\text{ N}$$

$$= 252\text{ N}$$

The bag does not hold.

Apparent weight



Situation	Formula	Explanation
At Rest or Moving at Constant Velocity	$F_{apparent} = F_g = m \cdot g$	The apparent weight equals the true weight because there is no net acceleration (a = 0).
Accelerating Upward	$F_{apparent} = m \cdot (g + a)$	The apparent weight increases because the scale must support both the true weight and the upward force.
Accelerating Downward	$F_{apparent} = m \cdot (g - a)$	The apparent weight decreases because the upward force from the scale is reduced due to downward acceleration.
Free Fall (Elevator Falling)	$F_{apparent} = 0$	In free fall, the apparent weight is zero because there is no upward force from the scale.
Decelerating While Moving Downward	$F_{apparent} = m \cdot (g + a)$	Apparent weight increases because the deceleration opposes the motion, acting as an upward force.
Decelerating While Moving Upward	$F_{apparent} = m \cdot (g - a)$	Apparent weight decreases because the deceleration reduces the net upward force.

Your mass is 75.0 kg, and you are standing on a bathroom scale in an elevator. Starting from rest, the elevator accelerates upward at 2.00 m/s^2 for 2.00 s and then continues at a constant speed.

What force would be exerted by the scale on a person in the following situations?

a. The elevator moves upward at constant speed.

Constant speed, so $a = 0$ and $F_{net} = 0$.

$F_{scale} = F_g$

$= mg = (75.0\text{ kg})(9.8\text{ N/kg})$

$= 735\text{ N}$

b. It slows at 2.0 m/s^2 while moving downward.

$a = 2.00\text{ m/s}^2$

$F_{scale} = F_{net} + F_g$

$= ma + mg$

$= (75.0\text{ kg})(2.00\text{ m/s}^2)$

$+ (75.0\text{ kg})(9.8\text{ N/kg})$

$= 150\text{ N} + 735\text{ N}$

$= 885\text{ N}$

c. It speeds up at 2.00 m/s^2 while moving downward.

$a = -2.00\text{ m/s}^2$

$F_{scale} = F_{net} + F_g$

$= ma + mg$

$= (75.0\text{ kg})(-2.00\text{ m/s}^2)$

$+ (75.0\text{ kg})(9.8\text{ N/kg})$

$= -150\text{ N} + 735\text{ N}$

$= 585\text{ N}$

d. It moves downward at constant speed.

Constant speed, so

$a = 0$ and $F_{net} = 0$

$F_{scale} = F_g = mg$

$= (75.0\text{ kg})(9.8\text{ N/kg})$

$= 735\text{ N}$

The acceleration of a 16.5 kg-object decreases from 5.0 m/s^2 to 3.0 m/s^2.

What is the change of the net force on the object?

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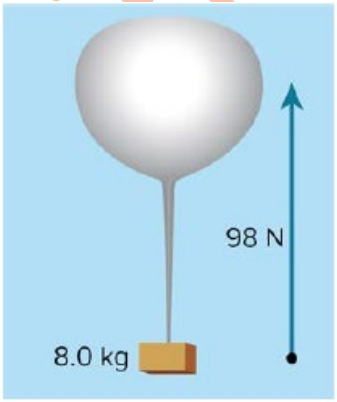
The instruments attached to a weather balloon in the image have a mass of 8.0 kg. The balloon is released and exerts an upward force of 98 N on the instruments.



a. **What is the acceleration of the balloon and the instruments?**

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b. **After the balloon has accelerated for 10.0 s, the instruments are released. What is the velocity of the instruments at the moment of their release?**

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c. **What net force acts on the instruments after their release?**

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d. **When does the direction of the instruments' velocity first become downward?**

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