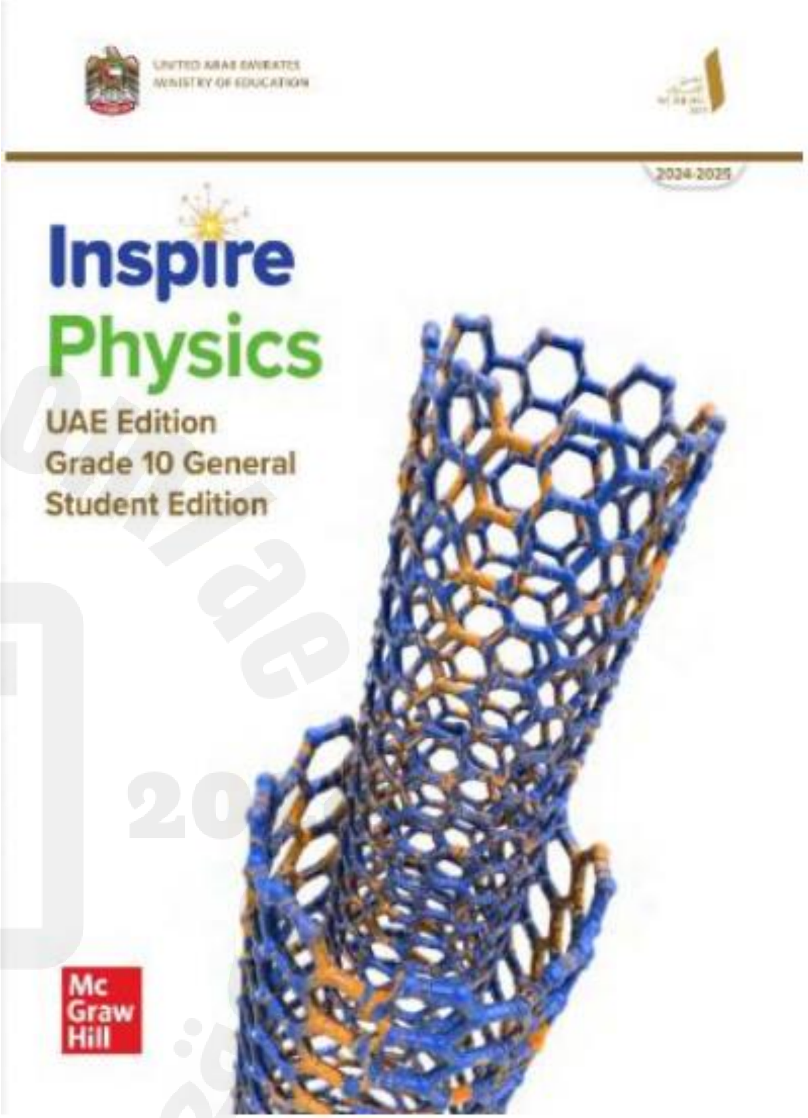
تجميعة صفحات الكتاب وفق الهيكل الوزاري القسم الورقي منهج انسباير

Academic Year العام الدراسي	2025/2024
Term الفصل	2
Subject الموضوع	Physics (INSPIRE)
Grade الصف	10
Stream. المسار	General العام

Number of FRQ **عدد الأسئلة المقالية**	4
Marks Per FRQ **الدرجات للأسئلة المقالية**	10



16	Combine forces to find the net force acting on an object. Apply Newton's Second Law to solve numerical problems. Find the equilibrant being the force having equal magnitude as the resultant force but opposite direction.	Student Textbook	85/88
		Example Problem (1)	89
		Get it	124

Figure 7 The net force acting on an object is the vector sum of all the forces acting on that object.

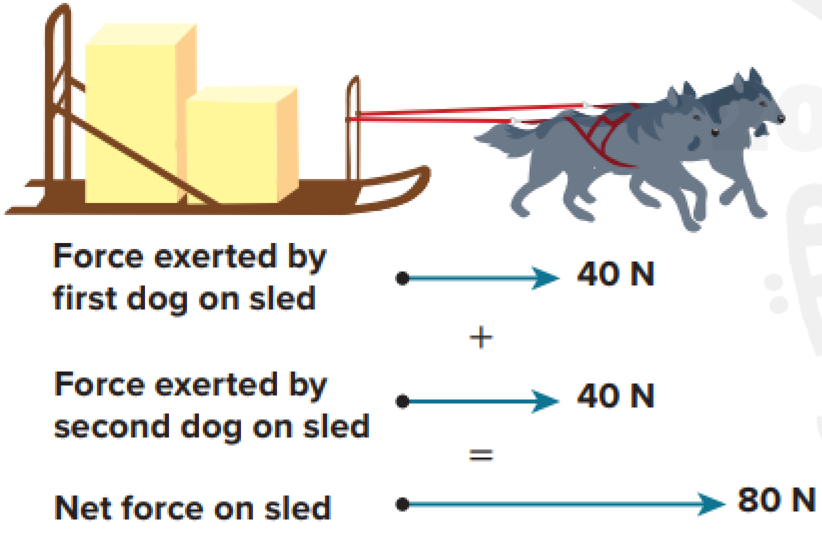
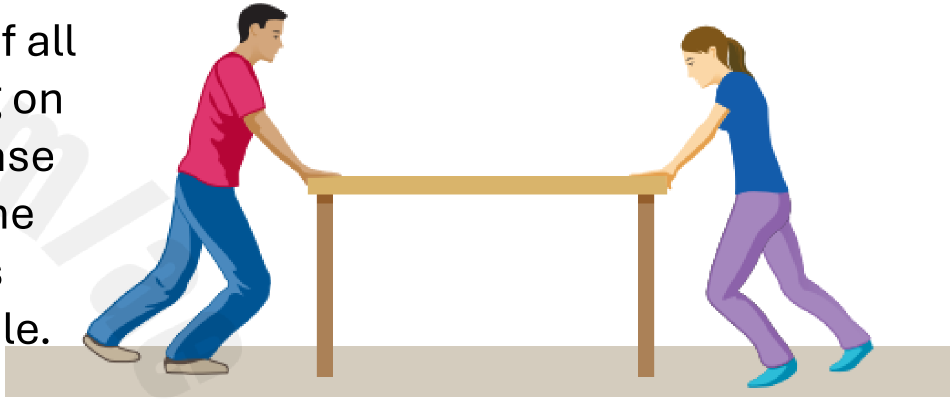
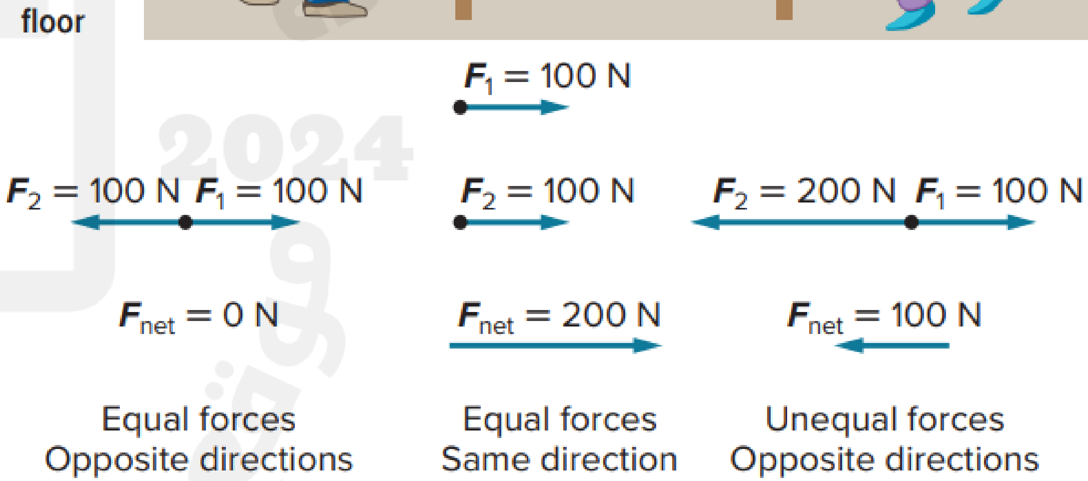


Figure 4 The net force acting on the table is the vector sum of all the forces acting on the table. This case only considers the horizontal forces acting on the table.





Newton's Second Law

The acceleration of an object is equal to the sum of the forces acting on the object divided by the mass of the object.

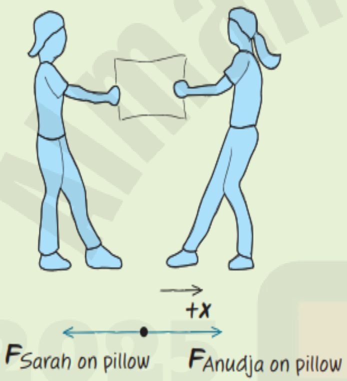
$$a = \frac{F_{net}}{m}$$

EXAMPLE Problem 1

FIGHTING OVER A PILLOW Anudja is holding a pillow with a mass of 0.30 kg when Sarah decides that she wants it and tries to pull it away from Anudja. If Sarah pulls horizontally on the pillow with a force of 10.0 N and Anudja pulls with a horizontal force of 11.0 N, what is the horizontal acceleration of the pillow?

1 ANALYZE AND SKETCH THE PROBLEM

- Sketch the situation.
- Identify the pillow as the system, and the direction in which Anudja pulls as positive.
- Draw the free-body diagram. Label the forces.



KNOWN	UNKNOWN
$m = 0.30$ kg	$a = ?$
$F_{Anudja\ on\ pillow} = 11.0$ N	
$F_{Sarah\ on\ pillow} = 10.0$ N	

2 SOLVE FOR THE UNKNOWN

$$F_{net} = F_{Anudja\ on\ pillow} + (-F_{Sarah\ on\ pillow})$$

Use Newton's second law.

$$a = \frac{F_{net}}{m}$$

$$= \frac{F_{Anudja\ on\ pillow} + (-F_{Sarah\ on\ pillow})}{m}$$

$$= \frac{11.0\text{ N} - 10.0\text{ N}}{0.30\text{ kg}}$$ Substitute $F_{Anudja\ on\ pillow} = 11.0$ N, $F_{Sarah\ on\ pillow} = 10.0$ N, $m = 0.30$ kg.

$$= 3.3\text{ m/s}^2$$

$\boldsymbol{a} = 3.3$ m/s^2 toward Anudja

PRACTICE Problems

6. Two horizontal forces, 225 N and 165 N, are exerted on a canoe. If these forces are applied in the same direction, find the net horizontal force on the dance.

7. If the same two forces as in the previous problem are exerted on the canoe in opposite directions, what is the net horizontal force on the canoe? Be sure to indicate the direction of the net force.

PRACTICE Problems ADDITIONAL PRACTICE

9. A spring scale is used to exert a net force of 2.7 N on a cart. If the cart's mass is 0.64 kg, what is the cart's acceleration?

10. Kamaria is learning how to ice skate. She wants her mother to pull her along so that she has an acceleration of 0.80 m/s^2. If Kamaria's mass is 27.2 kg, with what force does her mother need to pull her? (Neglect any resistance between the ice and Kamaria's skates.)

Get It?

Identify the relationship between the equilibrant and the resultant vector.

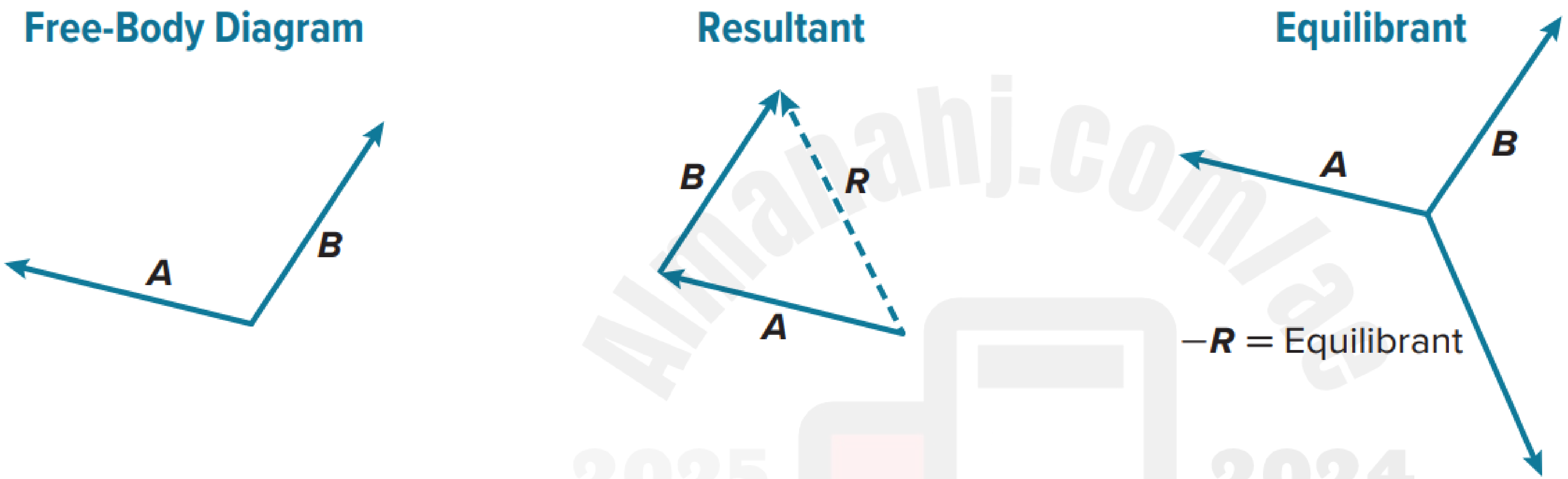
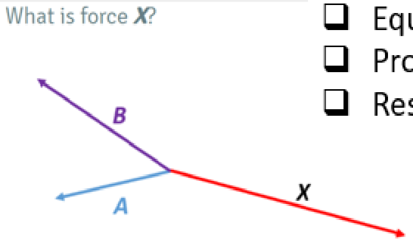


Figure 16 The equilibrant is the force required to put an object in equilibrium. This general procedure for finding the equilibrant works for any number of vectors.



- ❑ Equilibrant
- ❑ Product
- ❑ Resultant

2. Which is the term for a force that puts an object in equilibrium?

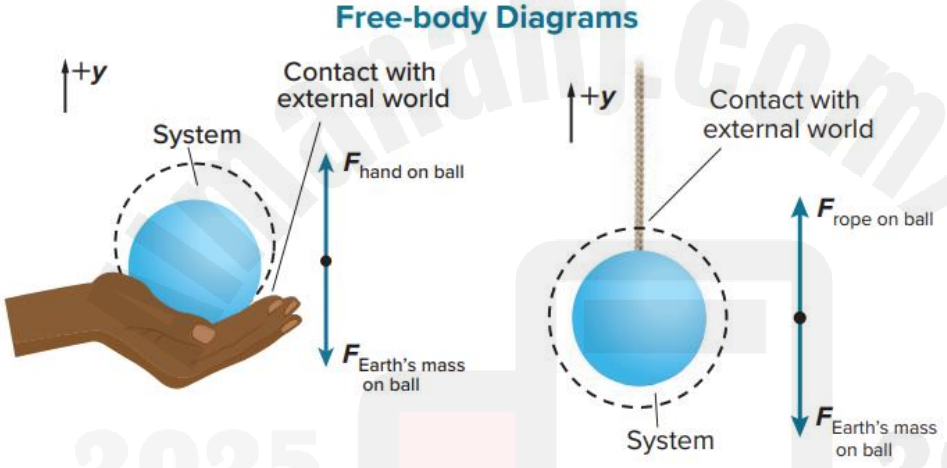
A. normal force
C. equilibrant
B. static friction force
D. resultant force

3. The equilibrant force has ______ magnitude compared to the resultant force, and it is in the ______ direction.

A. a greater / same
B. the same / opposite
C. the same / same
D. a smaller / opposite

17	↳ Draw the free body diagram showing the forces acting on an object (represented by a dot).	Student Textbook	84
	↳ Calculate the apparent weight for an object accelerating vertically upward or downward.	Example Problem (3)	95
	↳ Describe weightlessness and explain that an object with no contact supporting force experiences weightlessness.	Student Textbook	94

Figure 3 The drawings of the ball in the hand and the ball hanging from the string are both pictorial models. The free-body diagram for each situation is shown next to each pictorial model.



COLOR CONVENTION
Force (F) ⟷ blue

PRACTICE Problems

ADDITIONAL PRACTICE

For each of the following situations, specify the system and draw a motion diagram and a free-body diagram. Label all forces with their agents, and indicate the direction of the acceleration and of the net force. Draw vectors of appropriate lengths. Ignore air resistance unless otherwise indicated.

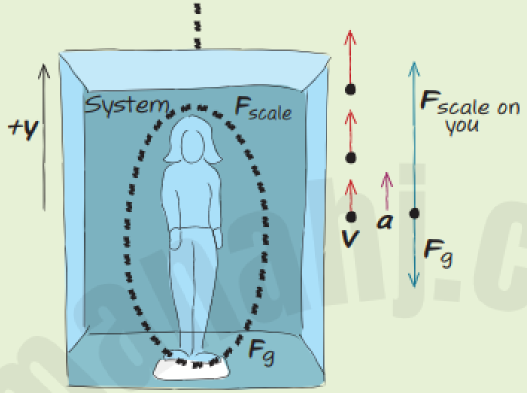
1. A skydiver falls downward through the air at constant velocity. (The air exerts an upward force on the person.)
2. You hold a softball in the palm of your hand and toss it up. Draw the diagrams while the ball is still touching your hand.
3. After the softball leaves your hand, it rises, slowing down.
4. After the softball reaches its maximum height, it falls down, speeding up.
5. **CHALLENGE** You catch the ball in your hand and bring it to rest.

EXAMPLE Problem 3

REAL AND APPARENT WEIGHT 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. Is the scale reading during acceleration greater than, equal to, or less than the scale reading when the elevator is at rest?

1 ANALYZE AND SKETCH THE PROBLEM

- Sketch the situation.
- Choose a coordinate system with the positive direction as upward.
- Draw the motion diagram. Label *v* and *a*.
- Draw the free-body diagram. The net force is in the same direction as the acceleration, so the upward force is greater than the downward force.



KNOWN	UNKNOWN
$m = 75.0$ kg	$F_{scale} = ?$
$a = 2.00\ m/s^2$	
$t = 2.00$ s	
$g = 9.8$ N/kg	

2 SOLVE FOR THE UNKNOWN

$F_{net} = ma$

$F_{net} = F_{scale} + (-F_g)$ — F_g is negative because it is in the negative direction defined by the coordinate system.

Solve for F_{scale}.

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

Elevator at rest:

$F_{scale} = F_{net} + F_g$ — The elevator is not accelerating. Thus, $F_{net} = 0.00$ N.

$= F_g$ — Substitute $F_{net} = 0.00$ N.

$= mg$ — Substitute $F_g = mg$.

$= (75.0\ kg)(9.8\ N/kg)$ — Substitute $m = 75.0$ kg, $g = 9.8$ N/kg.

$= 735$ N

Elevator accelerating upward:

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

$= ma + mg$ — Substitute $F_{net} = ma$, $F_g = mg$

$= (75.0\ kg)(2.00\ m/s^2) + (75.0\ kg)(9.8\ N/kg)$ — Substitute $m = 75.0$ kg, $a = 2.00\ m/s^2$, $g = 9.8$ N/kg

$= 885$ N

The scale reading when the elevator is accelerating (885 N) is larger than when it is at rest (735 N).

PRACTICE Problems — ADDITIONAL PRACTICE

20. On Earth, a scale shows that you weigh 585 N.

- **a.** What is your mass?
- **b.** What would the scale read on the Moon ($g = 1.60$ N/kg)?

21. CHALLENGE Use the results from Example Problem 3 to answer questions about a scale in an elevator on Earth. What force would be exerted by the scale on a person in the following situations?

- **a.** The elevator moves upward at constant speed.
- **b.** It slows at 2.0 m/s^2 while moving downward.
- **c.** It speeds up at 2.0 m/s^2 while moving downward.
- **d.** It moves downward at constant speed.
- **e.** In what direction is the net force as the elevator slows to a stop as it is moving down?

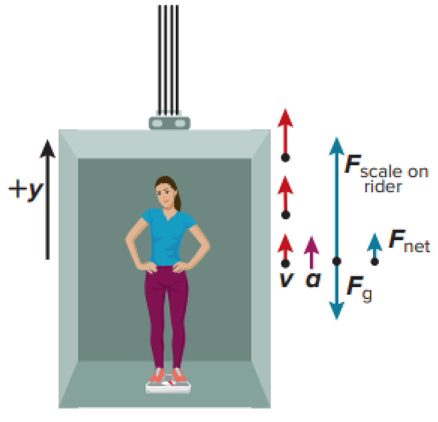


Figure 11 If you are accelerating upward, the net force acting on you must be upward. The scale must exert an upward force greater than the downward force of your weight.

If you ride in an elevator accelerating upward, you feel as if you are heavier because the floor presses harder on your feet. On the other hand, if the acceleration is downward, then you feel lighter, and the scale reads less than your weight. The force exerted by the scale is an example of **apparent weight,** which is the support force exerted on an object.

Imagine that the cable holding the elevator breaks. What would the scale read then? The scale and you would both accelerate at $a = g$. According to this formula, the scale would read zero and your apparent weight would be zero. That is, you would be weightless. However, **weightlessness** does not mean that an object's weight is actually zero; rather, it means that there are no contact forces acting to support the object, and the object's *apparent weight* is zero. Similar to the falling elevator, astronauts experience weightlessness in orbit because they and their spacecraft are in free fall.

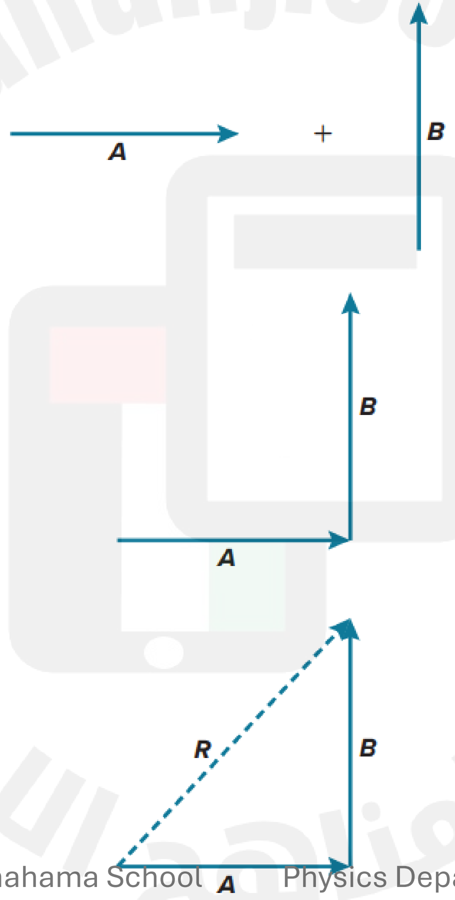
18	↳ Illustrate graphically the addition and subtraction of vectors in two dimensions.	Student Textbook	110
	↳ Determine the components of a vector in cartesian coordinate system using trigonometry.	Student Textbook	112
	↳ Draw a vector and determine its magnitude and direction given its components.	Example	113
	↳ Determine the resultant of two or more vectors algebraically by adding the components of the vectors and find its magnitude ($R^2=R_x^2 + R_y^2$) and direction ($\theta = \tan^{-1}(R_y/R_x)$).	Practice Problems (6)	116

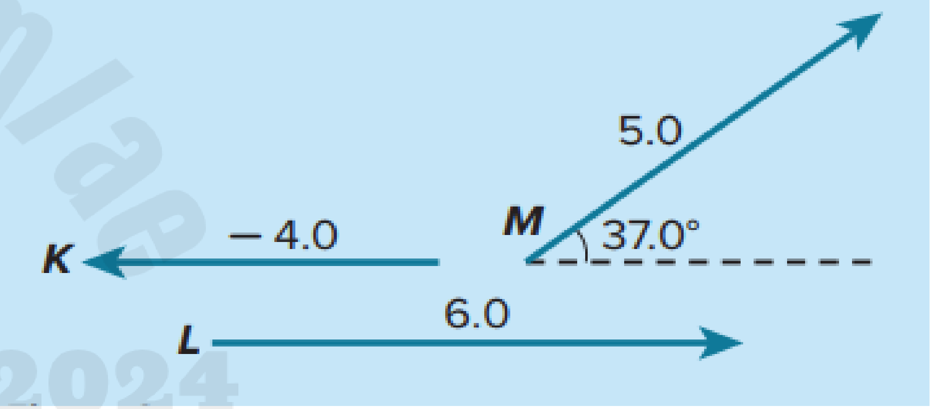
Adding vectors in two dimensions Even when vectors do not lie on a straight line, the resultant vector always points from the tail of the first vector to the tip of the final vector. You can use a protractor and a ruler both to draw the vectors at the correct angles and to measure the magnitude and the direction of the resultant vector.

Figure 2 illustrates how to add vectors graphically in two dimensions. Notice that when vector ***B*** is moved, its magnitude and direction are unchanged. This is always the case—you do not change a vector's length or direction when you move that vector.

Perpendicular vectors If you are adding together two vectors at right angles, such as vector ***A*** pointing east and vector ***B*** pointing north in **Figure 2,** you could use the Pythagorean theorem to find the magnitude (R) of the resultant vector.

$$R^2 = A^2 + B^2$$





1. Add vector L and K
2. Subtract vector K from vector L

Angles other than 90° If you are adding two vectors that are at an angle other than 90°, as in **Figure 3,** then you can use trigonometry, such as the law of sines or the law of cosines. It is best to use the law of sines when you are given two angle measurements and only one vector magnitude. The law of cosines is particularly useful when given two vectors and the angle between them.

Law of Sines: $\frac{R}{\sin\theta} = \frac{A}{\sin a} = \frac{B}{\sin b}$

Law of Cosines: $R^2 = A^2 + B^2 - 2AB\cos\theta$

What happens if you apply the law of cosines to a triangle in which $\theta = 90°$? Notice that the first three terms in the law of cosines are the same three terms found in the Pythagorean theorem. The final term in the law of cosines, $-2AB\cos\theta$, equals zero if $\theta = 90°$ because $\cos 90° = 0$.

$$R^2 = A^2 + B^2 - 2AB\cos 90°$$

$$R^2 = A^2 + B^2 - 2AB\,(0)$$

$$R^2 = A^2 + B^2$$

If $\theta = 90°$, the triangle is a right triangle and the law of cosines reduces to the Pythagorean theorem.

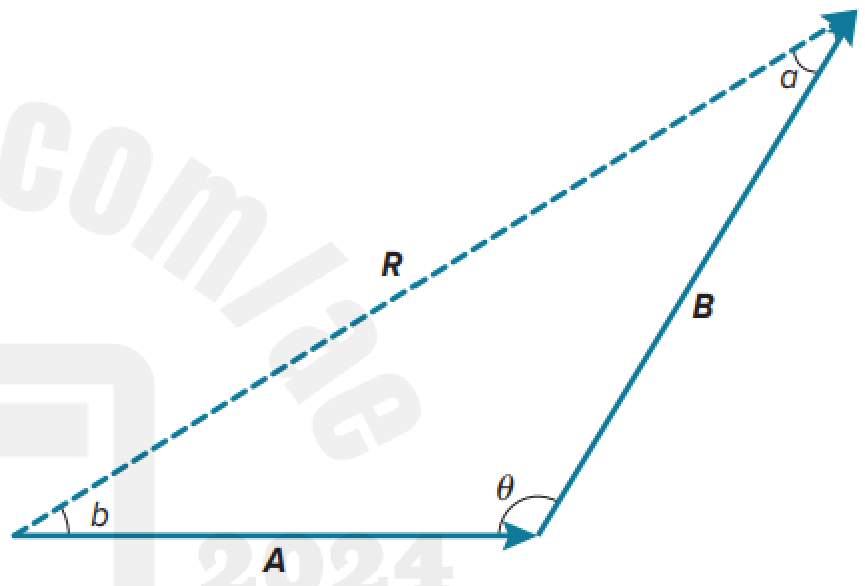


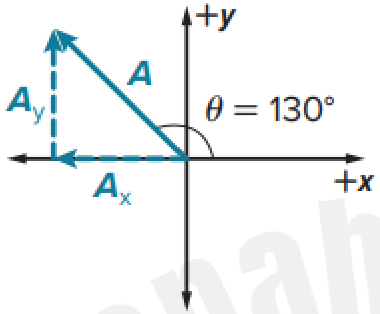
Figure 3 If the vectors are not at right angles, the Pythagorean theorem does not apply. Instead, use the law of cosines or the law of sines with the variables as shown here.

Vector Components

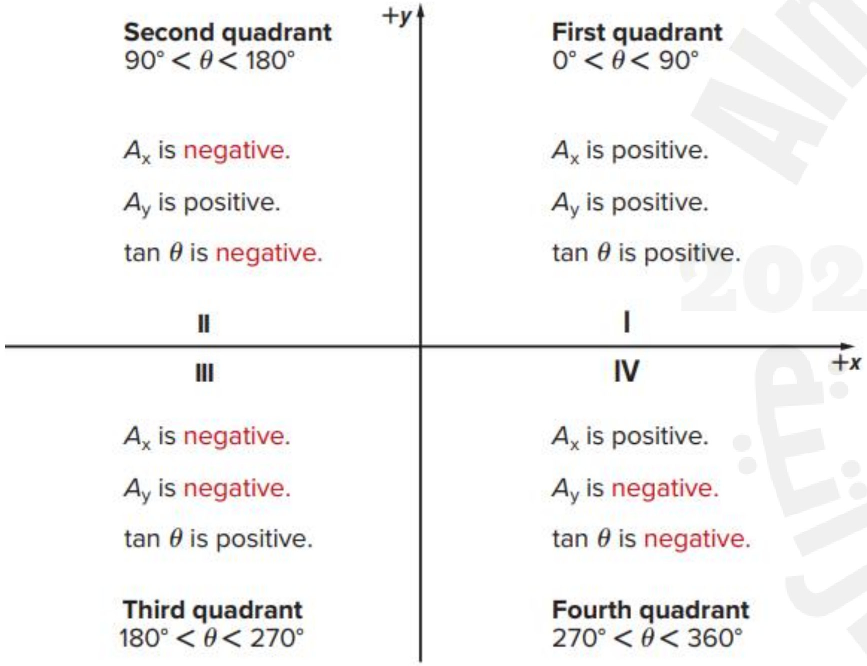
$$A_x = A \cos\theta$$

$$A_y = A \sin\theta$$

Example:



Coordinate System



Check Your Progress

11. **Vectors** Use **Figure 9** for these questions.
    a. Find the components of vectors ***K***, ***L***, and ***M***.
    b. Find the sum of the three vectors.
    c. Subtract vector ***K*** from vector ***L***.

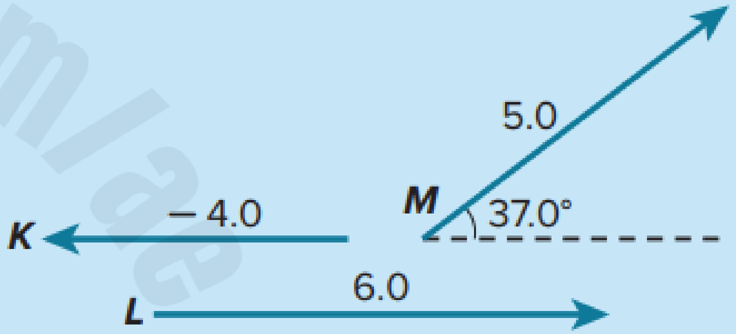


Figure 9

Algebraic Addition of Vectors

Figure 6 shows how resolving vectors into components makes adding vectors together easier. First, resolve each vector into its *x*- and *y*-components. Add the *x*-components to form the *x*-component of the resultant:

$$R_x = A_x + B_x + C_x.$$

Similarly, add the *y*-components to form the *y*-component of the resultant:

$$R_y = A_y + B_y + C_y.$$

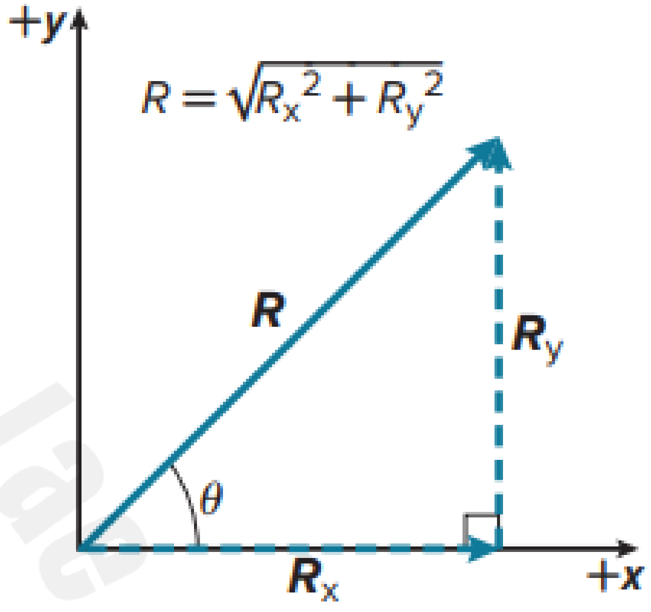
Because R_x and R_y are at a right angle (90°), you can calculate the magnitude of the resultant vector using the Pythagorean theorem:

$$R^2 = R_x^2 + R_y^2$$

Recall that the angle the vector makes with the *x*-axis is given by the following equation.

$$\theta = \tan^{-1}\left(\frac{R_y}{R_x}\right)$$

You can find the angle, or direction of the vector, using the $\tan^{-1}$ key on your calculator. When $\tan\theta > 0$, most calculators give the angle between 0° and 90°. When $\tan\theta < 0$, the angle will be between 0° and −90°.



Q.1 What is the magnitude of the resultant of two perpendicular vectors with lengths 3 and 4?

Q.2 You first walk 8.0 km north from home then walk east until your displacement from home is 10.0 km. How far east did you walk?

19	Identify the factors that friction force depends on.	Student Textbook	118-119
	Calculate the normal force on objects.	Student Textbook	103
	Apply the relationships that relate the normal force to maximum static friction and to kinetic friction to calculate unknown parameters like friction force, coefficient of friction or the normal force ($f_{static} \leq \mu_s N = f_{static,max}$ and $f_{kinetic} = \mu_k N$.	Example Problem (3)	120
	Solve problems related to friction	Practice Problems (15)	120

Depends on NORMAL Force

Depends on Type of Surface

Depends on State- At REST/ MOVING

ment. Table 1 shows the results of such an experiment.

Table 1 Kinetic Friction v. Normal Force (sandpaper)

Number of blocks	Normal force (N)	Kinetic friction (N)
1	0.98	0.53
2	1.96	0.95
3	2.94	1.4
4	3.92	1.8
5	4.90	2.3
6	5.88	3.1
7	6.86	3.3
8	7.84	4.0

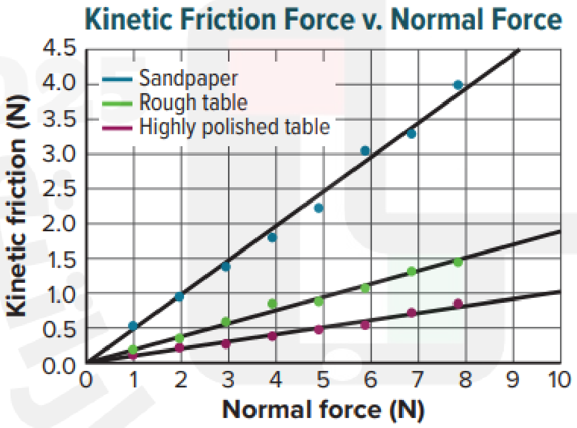


Figure 12 A plot of kinetic friction v. normal force for a block pulled along different surfaces shows a linear relationship between the two forces for each surface. The slope of the line is

Compare *the coefficient of kinetic friction for the three surfaces shown on the graph.*

Table 2 Typical Coefficients of Friction*

Surfaces	Coefficient of static friction (μ_s)	Coefficient of kinetic friction (μ_k)
Cast iron on cast iron	1.1	0.15
Glass on glass	0.94	0.4
Leather on oak	0.61	0.52
Nonstick coating on steel	0.04	0.04
Oak on oak	0.62	0.48
Steel on steel	0.78	0.42
Steel on steel (with castor oil)	0.15	0.08

*All measurements are for dry surfaces unless otherwise stated. All problems in this text assume dry surfaces.

The Normal Force

Any time two objects are in contact, they exert a force on each other. Consider a box sitting on a table. There is a downward force on the box due to gravity. There also is an upward force that the table exerts on the box. This force must exist because the box is in equilibrium. The **normal force** is the perpendicular contact force that a surface exerts on another surface.

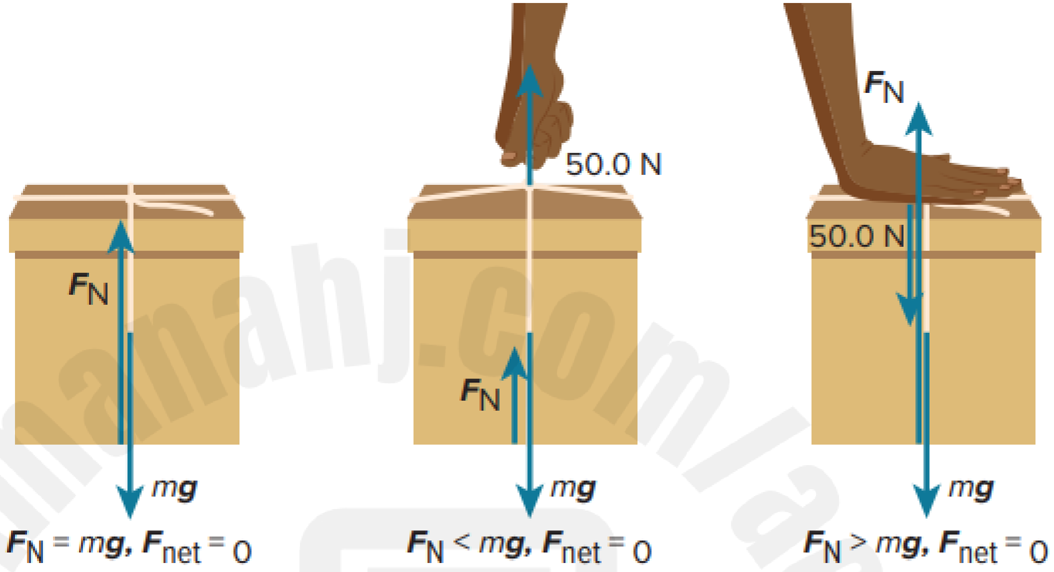


Figure 19 The normal force is not always equal to the object's weight.

The normal force always is perpendicular to the plane of contact between two objects, but is it always equal to the weight of an object? **Figure 19** shows three situations involving a box with the same weight. What if you tied a string to the box and pulled up on it a little bit, but not enough to accelerate the box, as shown in the middle panel in **Figure 19**? When you apply Newton's second law to the box and the forces acting on the box, you see $F_N + F_{\text{string on box}} - F_g = ma = 0$ N, which can be rearranged to show $F_N = F_g - F$ string on box.

You can see that in this case the normal force that the table exerts on the box is less than the box's weight (F_g). Similarly, if you pushed down on the box on the table as shown in the final panel in **Figure 19**, the normal force would be more than the box's weight. Finding the normal force will be important when you study friction in detail.

Kinetic Friction Force

The kinetic friction force equals the product of the coefficient of kinetic friction and the normal force.

$$F_{f,\ kinetic} = \mu_k F_N$$

Static Friction Force

The static friction force is less than or equal to the product of the coefficient of static friction and the normal force.

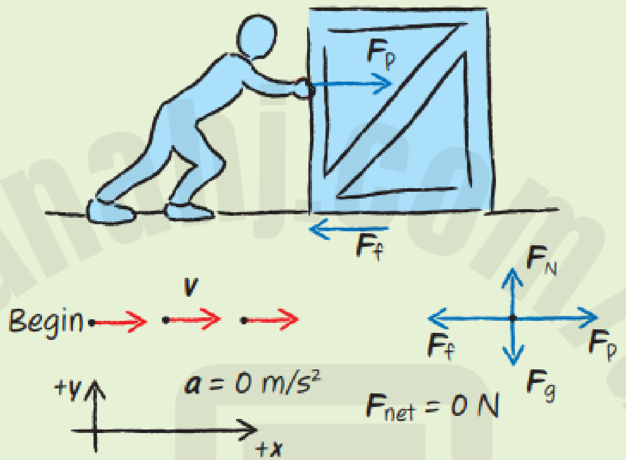
$$F_{f,\ static} = \mu_s F_N$$

EXAMPLE Problem 3

BALANCED FRICTION FORCES You push a 25.0-kg wooden box across a wooden floor at a constant speed of 1.0 m/s. The coefficient of kinetic friction is 0.20. How large is the force that you exert on the box?

1 ANALYZE AND SKETCH THE PROBLEM

- Identify the forces, and establish a coordinate system.
- Draw a motion diagram indicating constant v and $a = 0$.
- Draw the free-body diagram.



Known		Unknown
$m = 25.0$ kg	$v = 1.0$ m/s	$\mathbf{F}_{\text{person on box}} = ?$
$a = 0.0$ m/s²	$\mu_k = 0.20$	

2 SOLVE FOR THE UNKNOWN

The normal force is in the y-direction, and the box does not accelerate in that direction.

$$\mathbf{F}_N = -\mathbf{F}_g$$

$$= -mg \qquad \text{Substitute } F_g = -mg$$

$$= -(25.0\ \text{kg})(-9.8\ \text{N/kg}) \qquad \text{Substitute } m = 25.0\ \text{kg},\ g = -9.8\ \text{N/kg}$$

$$= +245\ \text{N}$$

The pushing force is in the x-direction; v is constant; thus the box does not accelerate.

$$F_{\text{person on box}} = \mu_k F_N$$

$$= (0.20)(245\ \text{N}) \qquad \text{Substitute } \mu_k = 0.20,\ F_N = 245\ \text{N}$$

$$= 49\ \text{N}$$

$$\mathbf{F}_{\text{person on box}} = 49\ \text{N, to the right}$$

PRACTICE Problems

15. Gwen exerts a 36-N horizontal force as she pulls a 52-N sled across a cement sidewalk at constant speed. What is the coefficient of kinetic friction between the sidewalk and the metal sled runners? Ignore air resistance.