CHAPTER I : FORCE AND MOTION II

Formative Practice 1.1

1. Determine the magnitude and direction of the resultant force in the following situations.

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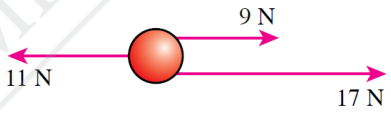
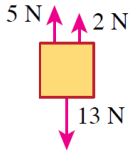


(b)



2. Figure 1.12 shows the forces acting on a ball that is kicked simultaneously by two players.

(a) Sketch a diagram that shows the 240 N force, the 180 N force and the resultant force.

(b) Calculate the magnitude of the resultant force on the ball.

(c) State the direction of motion of the ball.

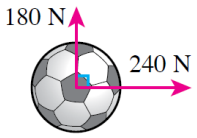
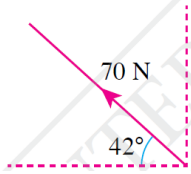


Figure 1.12

Formative Practice 1.2

1. Resolve the following forces into horizontal component and vertical component.

(a)



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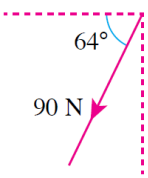


2. Figure 1.22 shows a man pushing a lawn mower with a force of 90 N.

(a) Resolve the pushing force into its horizontal component and vertical component.

(b) State the function of the horizontal component and vertical component of the pushing force when the lawn mower is being pushed.

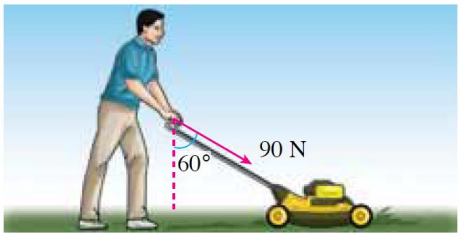


Figure 1.22

Formative Practice 1.3

1. State the meaning of forces in equilibrium.

2. Figure 1.31 shows a block that is stationary on an inclined plane when a stopping force, P is applied horizontally.

(a) Sketch and label the weight of the block, W and the normal reaction from the surface of the plane, R.

(b) Sketch the triangle of forces for P, W and R.

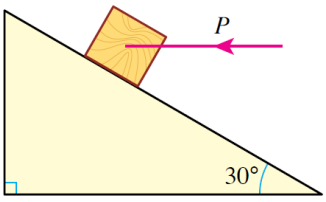


Figure 1.31

Formative Practice 1.4

1. What is the meaning of elasticity?

2. Figure 1.43 shows the graph of force, F against extension, x for a spring.
(a) State Hooke's law.
(b) Does the spring obey Hooke's law?
(c) Calculate the spring constant.
(d) What is the elastic potential energy in the spring when stretched to an extension of 0.04 m?

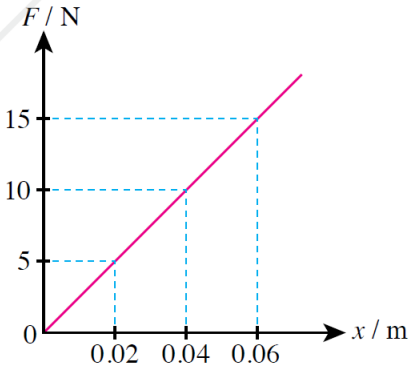


Figure 1.43

3. Figure 1.44 shows an arrangement consisting of three identical springs P, Q and R. The spring constant is 4 N cm^{-1}. The arrangement is compressed by an 8 N force. Determine:
(a) the force experienced by each spring
(b) the compression of each spring
(c) the compression of the system of springs

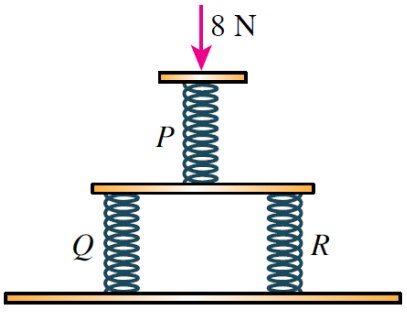


Figure 1.44

4. Figure 1.45 shows the graph of F against x for a spring. The shaded area in the graph has a value of 0.4 J.

(a) What is the force that produces the extension of 5 cm in the spring?

(b) Calculate the spring constant.

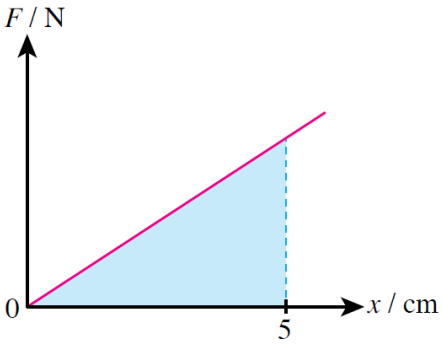


Figure 1.45

Summative Practice

1. Figure 1 shows the top view of a worker, X who is applying a pulling force of 70 N on a sack of flour on a track. Another worker, Y is able to apply a pulling force of 60 N on the sack. Determine the direction of the pulling force that must be applied by worker Y on the sack so that the sack moves along the line PQ.

[Ignore the friction between the sack and the surface of the track]

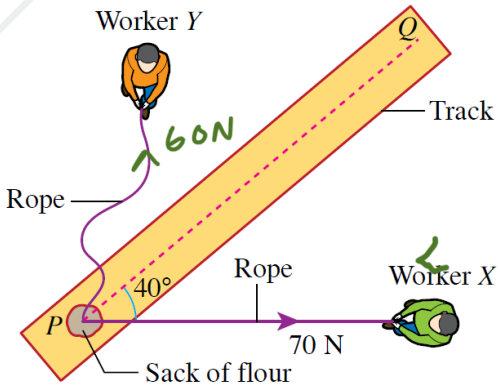


Figure 1

2. Figure 2 shows the top view of a pulling force applied by two persons, *P* and *Q* in an attempt to pull down a tree.

(a) By using the method of parallelogram of forces, determine the magnitude and direction of the resultant force on the tree.

(b) Discuss the advantage and disadvantage of having a large angle between the directions of the two forces.

(c) Which person has to be more careful when the tree begins to topple?

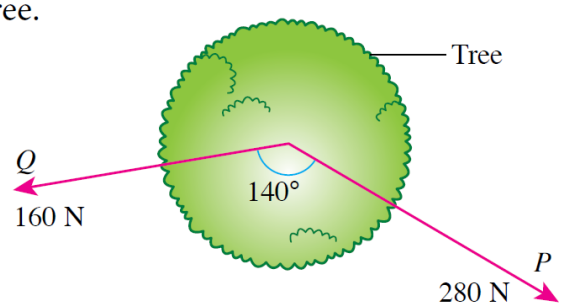


Figure 2

3. Figure 3 shows a children's playground equipment. The spring in the equipment experiences a compression of 5.0 cm when a child of mass 28 kg sits on it. What is the spring constant of the spring in N m^{-1}?
[Gravitational acceleration, g = 9.81 m s^{-2}]

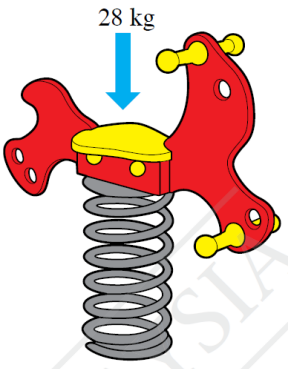


Figure 3

4. Justify the following statement.

When two forces of 17 N and 13 N act on a point, the resultant force produced cannot be smaller than 4 N or larger than 30 N.

5. The motion of a motorcycle of mass 180 kg is as follows.

Stage I: Stationary at a junction
Stage II: Moves towards the East with velocity that increases from zero to 20 m s^{-1} in a time of 8 s.
Stage III: Continues to move with a uniform velocity of 20 m s^{-1}.

For each stage, state the magnitude and direction of the resultant force on the motorcycle.

6. Figure 4 shows a chef exerting a force of 12 N to cut an onion.

(a) Calculate the horizontal component and vertical component of the 12 N force.

(b) What is the function of the horizontal component and vertical component in the action of cutting the onion?

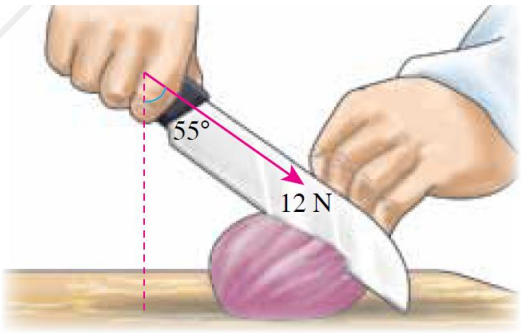


Figure 4

7. Figure 5 shows three forces acting on an object. The object is at rest. Calculate the magnitude of forces S and T.

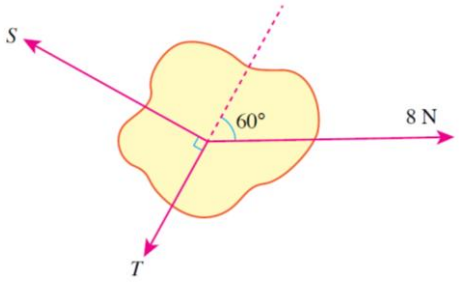
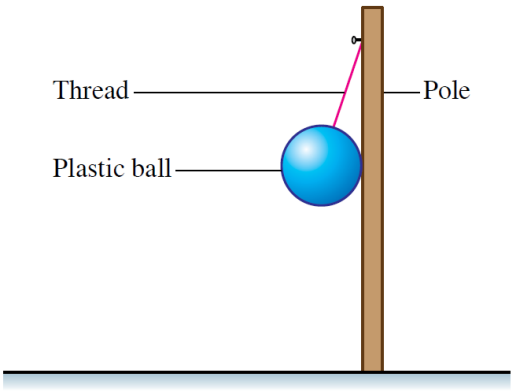
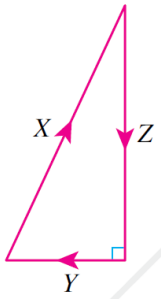


Figure 5

8. Figure 6(a) shows a plastic ball hanging from a pole. Figure 6(b) is the triangle of forces for forces X, Y and Z acting on the ball.
On Figure 6(a), sketch a free body diagram of the plastic ball.



(a)



(b)

Figure 6

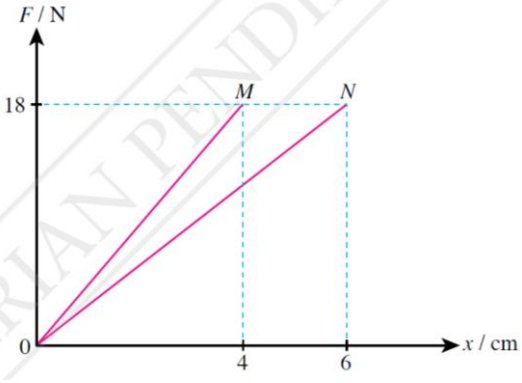
9. Three coplanar forces, 10 N, 24 N and 26 N act on an object. Draw a triangle of forces for the three forces if the object is in equilibrium.

10. Figure 7 shows the graph of force against extension for steel spring *M* and steel spring *N*.

(a) Calculate the spring constant for steel spring *M*.

(b) What is the elastic potential energy stored in steel spring *N* when it is stretched to an extension of 6 cm?

(c) Compare and contrast steel spring *M* with steel spring *N*.



11. A spring stores elastic potential energy of 18 J when the extension of the spring is 4.0 cm. What is the force required to stretch the spring to an extension of 3.0 cm?

12. A technician was assigned to study the use of three types of springs, *X*, *Y* and *Z* with spring constants given in Table 1.

(a) Table 2 shows four arrangements of springs considered by the technician.

Table 1

Types of spring	Spring constant / N cm^{-1}
X	200
Y	300
Z	600

Table 2

Arrangement	Force applied / N	Extension of system of springs / cm
Two springs of type *X* in series	400	
Two springs of type *X* in parallel	600	
Two springs of type *Y* in series	300	
Two springs of type *Z* in parallel	600	

For each arrangement of springs, determine the extension and complete Table 2.

(b) What is the assumption that you have made based on your calculation in 12(a)?

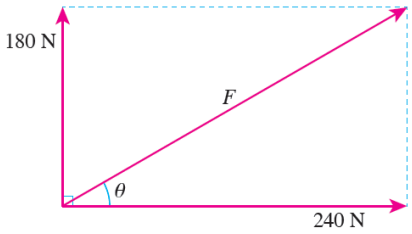
ANSWERS

Formative Practice 1.1

1. (a) Resultant force = 9 + 17 + (–11)
= 15 N to the right

(b) Resultant force = 13 + (–5) + (–2)
= 6 N downwards

2. (a)



F = resultant force

(b) $F = \sqrt{240^2 + 180^2}$
$F = 300$ N

(c) Moves along the direction of the resultant force

$\theta = \tan^{-1}\left(\frac{180}{240}\right)$
$= 36.87°$

Formative Practice 1.2

1. (a) Horizontal component = 70 cos 42°
= 52.02 N
Vertical component = 70 sin 42°
= 46.84 N

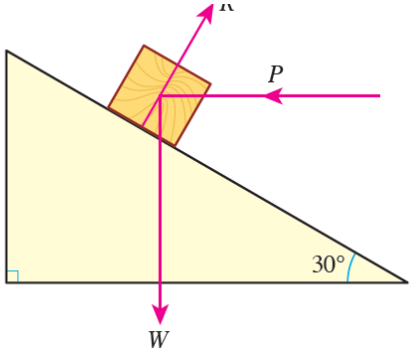
(b) Horizontal component = 90 cos 64°
= 39.45 N
Vertical component = 90 sin 64°
= 80.89 N

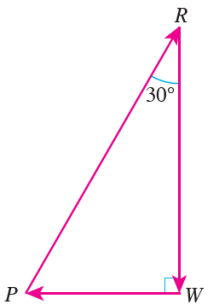
2. (a) Horizontal component = 90 sin 60°
= 77.94 N
Vertical component = 90 cos 60°
= 45.00 N

(b) The horizontal component moves the lawn mower forward.
The vertical component pushes the lawn mower on the surface of the field.

Formative Practice 1.3

1. An object is said to be in equilibrium of forces when the forces acting on it produce a zero resultant force.





Formative Practice 1.4

1. Elasticity is the property of material that enables an object to return to its original shape and size when the force applied on it is removed.

2. (a) Hooke's law states that the extension of a spring is directly proportional to the force applied on the spring provided the elastic limit of the spring is not exceeded.

(b) The spring obeys Hooke's law because the graph is a straight line passing through the origin.

(c) Spring constant, k
= gradient of the graph F against x
$= \frac{15}{0.06}$
$= 250$ N m^{-1}

(d) Elastic potential energy = area under the graph
$= \frac{1}{2} \times 0.04 \times 10$
$= 0.2$ J

3. (a) Spring P = 8 N
Spring Q = 4 N
Spring R = 4 N

(b) $F = kx$, $k = 4$ N cm^{-1}
Compression, $x = \frac{F}{k}$
Spring P: $x = \frac{8}{4}$
$= 2$ cm

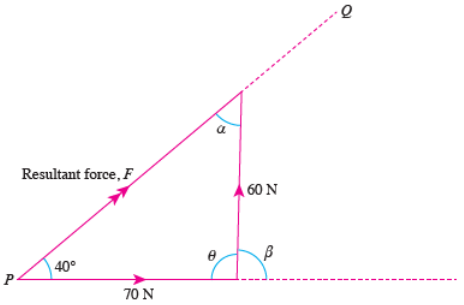
(c) Total compression = 2 + 1
= 3 cm

4. (a) Extension = 5 cm
= 0.05 m
Force that produces an extension 0.05 m = F
Elastic potential energy = Shaded area
$0.4 = \frac{1}{2} \times 0.05 \times F$
$F = 16$ N

(b) Force, $F = 16$ N
Extension, $x = 0.05$ m
$F = kx$
Spring constant, $k = \frac{F}{x}$
$= \frac{16}{0.05}$
$= 320$ N m^{-1}

Summative Practice

1. The resultant force of worker X (70 N) and worker Y (60 N) has to act along the line PQ. The triangle of forces for forces 70 N, 60 N and resultant force, F is as follows:



Using the sine rule,

$$\frac{70}{\sin \alpha} = \frac{60}{\sin 40°}$$

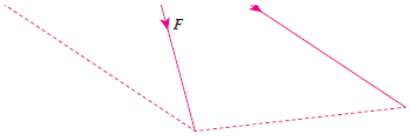
$$\sin \alpha = \frac{70 \times \sin 40°}{60}$$

$$\alpha = 48.58°$$

$$\theta = 180 - 40 - 48.58$$
$$= 91.42°$$

$$\beta = 180 - 91.42$$
$$= 88.58°$$

Therefore, worker Y has to apply a force that makes an angle of 88.58° with the direction of the force from worker X.



Length of the diagonal of the parallelogram = 9.4 cm

Resultant force, $F = 9.4 \times 20$
$= 188$ N

$F = 188$ N at an angle of 33° with the direction of the force applied by P.

(b) – Advantage: The tree will fall in the direction of the resultant force. A larger angle will ensure that there is a large space between P and Q. The tree will fall on to the ground without endangering P dan Q.
– Disadvantage: The large angle between the directions of the forces produces a resultant force with a smaller magnitude.

(c) The direction of the resultant force makes a smaller angle with the direction of the force by P. The tree will fall nearer to P. Therefore, P has to be more careful.

3. Force on spring, F = weight of child
$= mg$
$= 28 \times 9.81$
$= 274.68$ N

Compression, $x = 5.0$ cm
$= 0.05$ m

From $F = kx$

$$k = \frac{F}{x}$$

$$= \frac{274.68}{0.05}$$

$= 5\,493.6$ N m^{-1}

4. The resultant force of the two forces has the largest magnitude when the forces act on an object in the same direction.
If the force 17 N and the force 13 N are in the same direction, resultant force = 17 + 13
= 30 N

The resultant force of the two forces has the smallest magnitude when the forces are in opposite directions.
If the force 17 N and the force 13 N are in opposite directions, resultant force = 17 + (–13)
= 4 N

Therefore, the resultant forces of 17 N and 13 N has magnitude between 4 N and 30 N.

5. Stage I: For a stationary object, velocity = 0 and acceleration, $a = 0$.
Resultant force, $F = ma$
$F = 0$ N

Stage II: $u = 0$, $v = 20$ m s^{-1}, $t = 8$ s

Acceleration, $a = \frac{20 - 0}{8}$
$= 2.5$ m s^{-2}

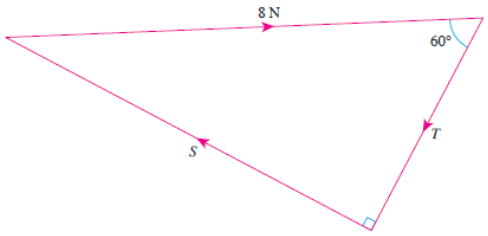
Resultant force, $F = 180 \times 2.5$
$= 450$ N to the East

Stage III: For an object moving with a uniform velocity, acceleration, $a = 0$.
Resultant force, $F = ma$
$F = 0$ N

6. (a) Horizontal component = 12 sin 55°
= 9.83 N
Vertical component = 12 cos 55°
= 6.88 N

(b) The horizontal component moves the knife forward.
The vertical component pushes the knife downward.

7. Three forces S, T and 8 N form a triangle when drawn in sequence.

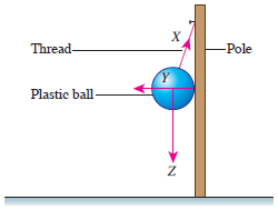


$$\frac{T}{8} = \cos 60°$$

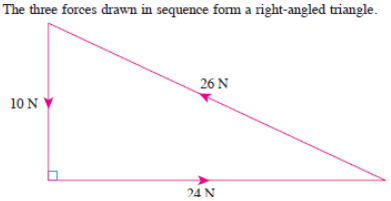
$$T = 8 \cos 60°$$
$= 4.0$ N

$$S = \sqrt{8^2 - 4^2}$$
$= 6.93$ N

8.



9. Since the object is stationary, the three coplanar forces 10 N, 24 N, 26 N are in equilibrium.
$10^2 + 24^2 = 676$
$26^2 = 676$
That is, $10^2 + 24^2 = 26^2$
The three forces drawn in sequence form a right-angled triangle.



10. (a) Spring M: force $F = 18$ N produces an extension, $x = 4$ cm
$= 0.04$ m

Spring constant of spring $M = \frac{18}{0.04}$
$= 450$ N m^{-1}

(b) Spring N: extension, $x = 6$ cm
$= 0.06$ m

Elastic potential energy $= \frac{1}{2} \times 0.06 \times 18$
$= 0.54$ J

(c) The graph for both springs are straight lines passing through the origin.
Both springs obey Hooke's law.
Spring N obeys Hooke's law to a greater extension than spring M.
Gradient of graph M > gradient of graph N
Spring constant M > spring constant N
Spring M is stiffer than spring N.

When an 18 N force is applied, the area under the graph N is larger than the area under the graph M.

Spring N stores more elastic potential energy than spring M when both springs are stretched by the same force.

11. Elastic potential energy, $E_p = 18$ J
Extension of spring, $x = 4.0$ cm
$= 0.04$ m

$$E_p = \frac{1}{2}kx^2$$

$$\frac{1}{2} \times k \times 0.04^2 = 18$$

$k = 22\,500$ N m^{-1}

When $x = 3.0$ cm
$= 0.03$ m

$F = kx$
$= 22\,500 \times 0.03$
$= 675$ N

12. (a) The extension of a spring is calculated as follows:
$F = kx$
Extension, $x = \frac{F}{k}$

Arrangement	Force applied / N	Tension in one spring / N	Extension of one spring / cm	Extension of system of springs /cm
Two springs of type X in series	400	400	2.00	4.00
Two springs of type X parallel	600	300	1.50	1.50
Two springs of type Y in series	300	300	1.00	2.00
Two springs of type Z parallel	600	300	0.50	0.50

(b) Each spring obeys Hooke's law.