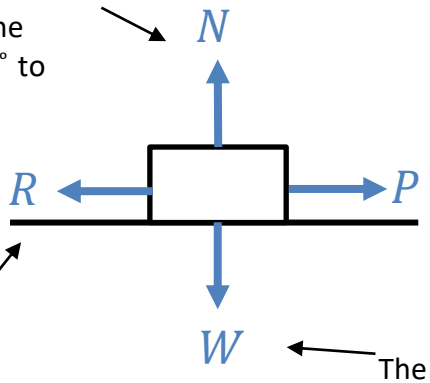
M1 Chapter 10: Forces and Motion

Force Diagrams

Force Diagrams (Free Body Diagrams)

The **normal support force** of the plane on the block (holding up the block; always at 90° to the surface.)



Force pulling the block. When a string/cable is involved, this is tension T.

Resistive force: in this case the **friction** between the block and the plane.

The weight of the block.

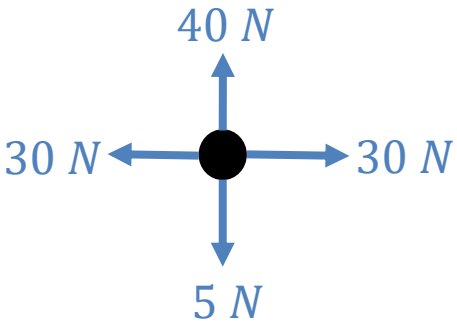
We consider the forces acting on each object one at a time.

Recall that we often model an object as a **particle**, i.e. a point with negligible dimensions.

Newton's 1st Law of Motion states than an object at rest will stay at rest and that an object moving with constant velocity will remain at that velocity unless an unbalanced force acts on the object.

Resultant forces need to be non-zero to cause acceleration.
If forces are balanced in every direction there will be no acceleration.
e.g. forces up = forces down & forces left = forces right.

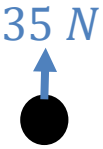
The '**resultant force**' is the overall force acting on the object. An object will accelerate in the direction of the resultant force.



$R(\uparrow)$: $40 - 5 = 35\ N$

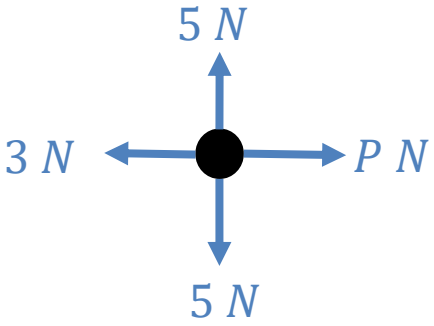
$R(\rightarrow)$: $30 - 30 = 0\ N$

We use $R(\ )$ to 'resolve' the forces in a particular direction. **This is standard notation for use in exams.**



Therefore a 'resultant' force of 35 N upwards and the object will accelerate upwards.

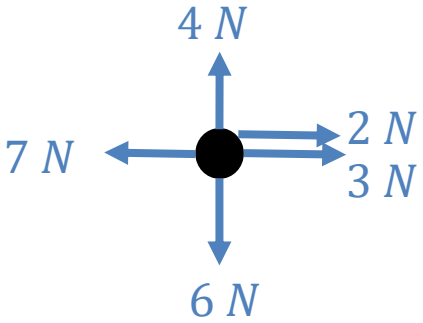
Quickfire Examples



$R(\uparrow)$: ?

$R(\rightarrow)$: ?

? Resultant Force



$R(\uparrow)$: ?

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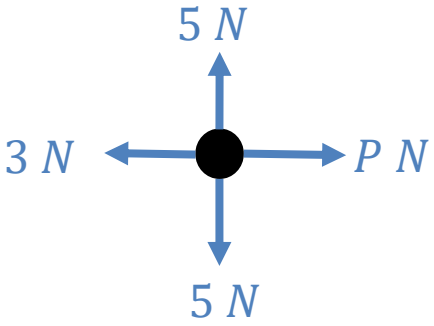
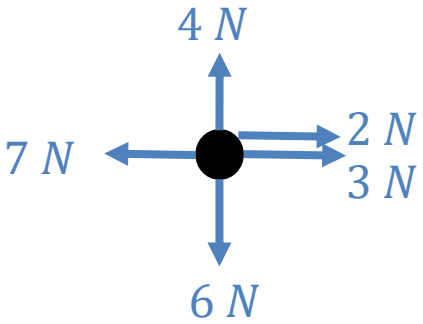
? Resultant Force

Quickfire Examples



$R(\uparrow)$: $5 - 5 = 0\ N$

$R(\rightarrow)$: $(P - 3)\ N$



$R(\uparrow)$: $4 - 6 = -2\ N$

$R(\rightarrow)$: $5 - 7 = -2\ N$

We'll worry about the magnitude of this force in a sec…

Exercise 10.1 Force Diagrams

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Homework Exercise

1 A box is at rest on a horizontal table. Draw a force diagram to show all the forces acting on the box.

2 A trapeze bar is suspended motionless from the ceiling by two ropes. Draw a force diagram to show the forces acting on the ropes and the trapeze bar.

3 Ignoring air resistance, draw a diagram to show the forces acting on an apple as it falls from a tree.

4 A car's engine applies a force parallel to the surface of a horizontal road that causes the car to move with constant velocity. Considering the resistance to motion, draw a diagram to show the forces acting on the car.

5 An air–sea rescue crew member is suspended motionless from a helicopter. Ignoring air resistance, show all the forces acting on him.

6 A satellite orbits the Earth at constant speed. State, with a reason, whether any resultant force is acting on the satellite.

Problem-solving

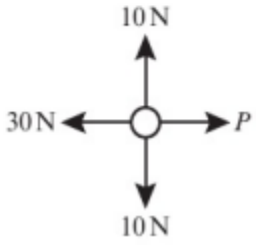
Consider the velocity of the satellite as it orbits the Earth.

7 A particle of weight 5 N sits at rest on a horizontal plane. State the value of the normal reaction acting on the particle.

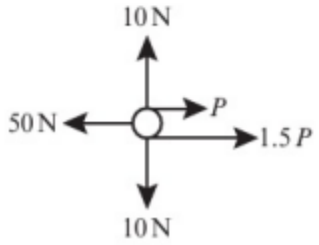
8 Given that each of the particles is stationary, work out the value of P:

a

b



c



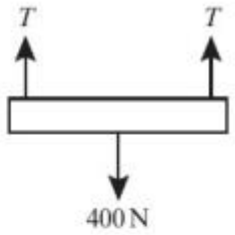
Homework Exercise

9 A hoist lifts a platform vertically at constant velocity as shown in the diagram.

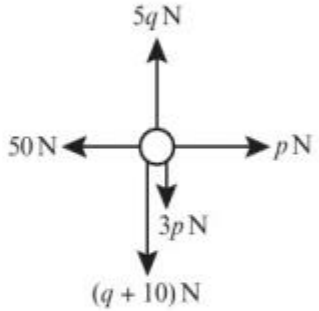
a Ignoring air resistance, work out the tension, T in each rope.

The tension in each rope is reduced by 50 N.

b Describe the resulting motion of the platform.



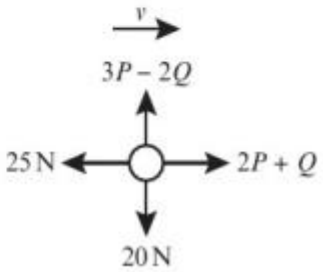
10 The diagram shows a particle acted on by a set of forces.
Given that the particle is at rest, find the value of p and the value of q.



11 Given that the particle in this diagram is moving with constant velocity, v, find the values of P and Q.

Problem-solving

Set up two simultaneous equations.



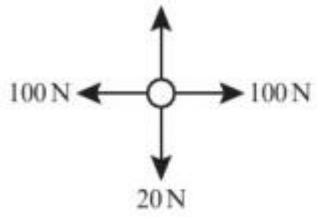
Homework Exercise

12 Each diagram shows the forces acting on a particle.

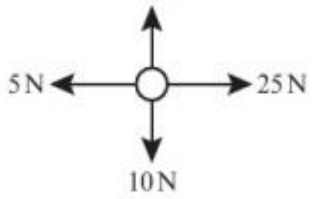
i Work out the size and direction of the resultant force.

ii Describe the motion of the particle.

a



b



13 A truck is moving along a horizontal level road. The truck's engine provides a forward thrust of 10 000 N. The total resistance is modelled as a constant force of magnitude 1600 N.

a Modelling the truck as a particle, draw a force diagram to show the forces acting on the truck.

b Calculate the resultant force acting on the truck.

14 A car is moving along a horizontal level road. The car's engine provides a constant driving force. The motion of the car is opposed by a constant resistance.

a Modelling the car as a particle, draw a force diagram to show the forces acting on the car.

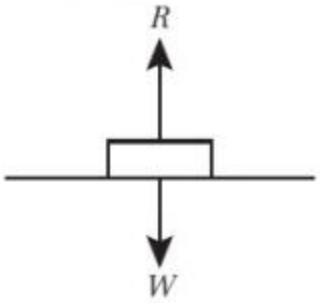
b Given that the resultant force acting on the car is 4200 N in the direction of motion, and that the magnitude of the driving force is eight times the magnitude of the resistance force, calculate the magnitude of the resistance.

Problem-solving

Use algebra to describe the relationship between the driving force and the resistance.

Homework Answers

1



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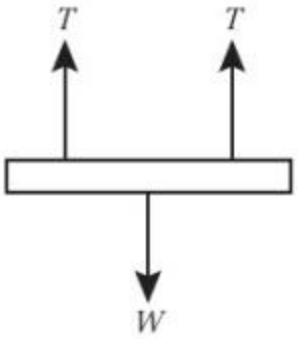

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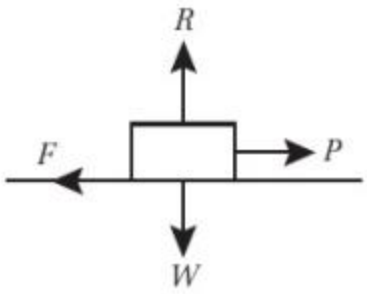


5

6 Although its speed is constant, the satellite is continuously changing direction. This means that the velocity changes. Therefore, there must be a resultant force on the satellite.

7 5N

8 **a** 10N **b** 30N **c** 20N

9 **a** 200N

b The platform accelerates towards the ground.

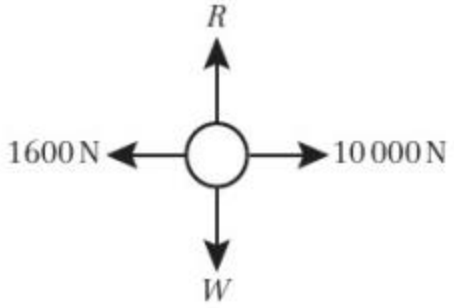
10 $p = 50$, $q = 40$

11 $P = 10\,\text{N}$, $Q = 5\,\text{N}$

12 **a** **i** 20N **ii** vertically upwards

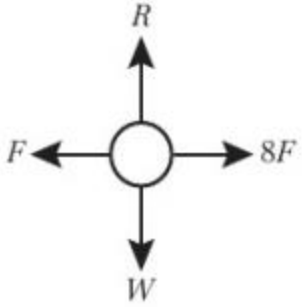
b **i** 20N **ii** to the right

13 **a**



b 8400N

14 **a**



b 600N