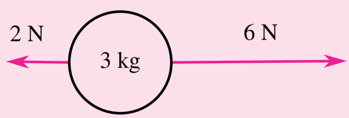
13 Resultant Force and Acceleration

The resultant force on an object is:

- the force left over after equal and opposite forces have cancelled out;
- the one force which would have the same effect as all of the forces;
- the vector sum of the forces on the object.

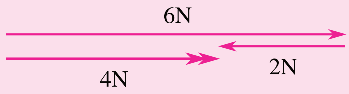
Example 1 – Calculate the resultant force on this object.



2 N force to left cancels out 2 N of the 6 N of the right force, leaving $6\text{ N} - 2\text{ N} = 4\text{ N}$ to the right left over.

Or you can answer: The two forces are $+6$ N and -2 N. Adding gives 4 N.

Or you can add the vector arrows 'nose to tail' to get a resultant 4 N answer:



[A double arrow symbol here denotes a resultant vector.]

13.1 For these questions, refer to the diagrams that follow.

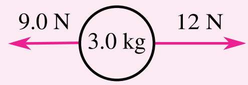
(a) Work out the size (strength) and direction of the resultant forces for each object. *[Hint for (vi): draw the vectors nose to tail and think 'Pythagoras'.]*

(b) Work out the size and direction of the extra force which would need to be added in order to achieve equilibrium (zero resultant force) for each object.

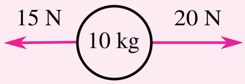
(c) Compare your answers to (a) and (b). What do you notice?

(i)

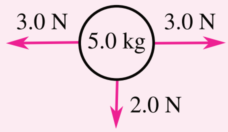
(ii)



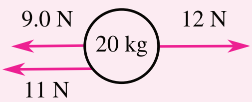
(iii)



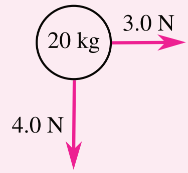
(iv)



(v)



(vi)



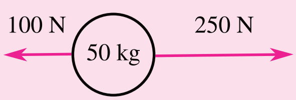
If you need more practice, turn back to Vectors and Scalars - P9 and try to balance the forces in Q4.9.

The acceleration of an object depends on the:

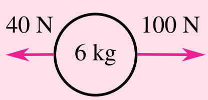
- resultant force acting on the object;
- mass of the object.

Example 2 – Which of these objects will have the greater acceleration?

(a)



(b)



(a) has resultant 150 N to the right, acting on 50 kg of mass. This means $150\text{ N}/50\text{ kg} = 3\text{ N/kg}$, i.e. 3 N acting on each kilogram.
(b) has resultant 60 N to the right, acting on 6 kg of mass. This means

60 N / 6 kg = 10 N/kg, i.e. 10 N acting on each kilogram.
Therefore, object (b) will have the greater acceleration.

Formula:

$$\text{acceleration (m/s}^2) = \text{resultant force (N) / mass (kg)} \qquad a = F/m$$

Usually written:

$$\text{resultant force (N)} = \text{mass (kg)} \times \text{acceleration (m/s}^2) \qquad F = ma$$

13.2 Calculate the acceleration of each of the objects in Q13.1.

13.3 Complete the table. Each row represents a different question.

Resultant Force (N)	**Mass (kg)**	**Acceleration (m/s^2)**
(a)	810	6.7
(b)	430 000	2.6
2 000	65	(c)
(d)	10 g	9.8

13.4 A 100 g mass has weight of 1.00 N.

(a) If this is the only force on the mass, what is its acceleration?

(b) What would be the weight of a 300 g mass in the same gravitational field?

(c) If the weight is the only force on the 300 g mass, what is its acceleration?

A resultant force in the direction of motion speeds an object up.
A resultant force opposite to the direction of motion slows it down.
Zero resultant force means that the object keeps a steady velocity.

13.5 Complete the table. Each row describes a different object which has two forces acting upon it– one forwards (in the direction of motion), one backwards. Define forces and accelerations acting forwards as positive. Is each object speeding up or slowing down?

Force (N)			Mass (kg)	Acceleration (m/s^2)
Forwards	Backwards	Resultant		
58	16	(a)	5.6	(b)
90	145	(c)	22	(d)
(e)	350	(f)	120	+6.7

13.6 What unbalanced force acts on a 70 kg mass accelerating at 1.6 m/s^2?

13.7 What is the acceleration of a 10 kg mass which has no unbalanced force acting on it?

13.8 A 1 200 kg vehicle is accelerating along a straight road at 3.0 m/s^2. What is the magnitude of the unbalanced force acting on it?

13.9 What force must I apply to a mass of 3.0 kg to accelerate it at 4.0 m/s^2 on a horizontal surface if

(a) there is no friction and;

(b) there is friction of 4.0 N?

13.10 The thrust generated by a rocket engine is equal to the mass of propellant burnt each second multiplied by the exhaust velocity of the gas. The Space Shuttle (with booster rockets and external tank) had a total mass of 2 040 000 kg at launch. In this question we shall assume that the exhaust velocity of the gas was 3 000 m/s.

(a) How much propellant would have to be burnt each second in order for the spacecraft to just lift off?

(b) How much propellant would have to be burnt each second in order for the spacecraft to accelerate upwards from the launch pad at “3g” (i.e. 30 m/s^2)?

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Additional Resultant Force and Acceleration – on-line

isaacphysics.org/gameboards#phys_book_gcse_ch_2_13_add