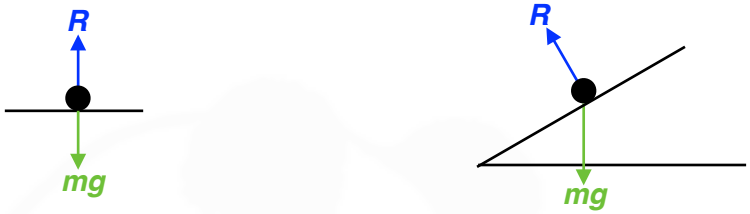
Normal Reaction Force

Notes

Normal reaction or normal contact force, R

When an object is in contact with a surface, there is a force on the object ***at right angles to the surface of contact***. This is called the normal contact force or normal reaction force, R.



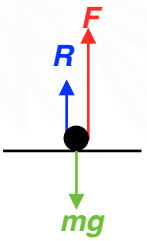
If ***no other forces*** are acting and there is no acceleration, the normal contact force, ***R, equals the weight*** of the object.

N.B. $R \geq 0$ — if you resolve and find R is negative, it means the object is no longer in contact with the surface.
When $R = 0$, the object is just about to lift off the surface

Pushing down and pulling up on an object

E.g. 1 A book, of mass m, is resting on a table. Does the normal reaction force increase or decrease when we:
(a) pull up on the book
(b) push down on the book?

E.g. 2 A mass of 5 kg rests on a table. Find the normal reaction force, R, between the object and the table mass 5 kg when the mass is pulled up with a force, F, where:
(a) $F = 0$ N (i.e. no force)
(b) $F = 20$ N
(c) $F = 49$ N
(d) $F = 50$ N
(e) What happens to the normal reaction force if a force pushes down on an object with a force of 20 N?



Working: We resolve vertically $R(\uparrow)$: to see the resultant force

(a) $R(\uparrow)$: $R = mg = 5g = 49$ N

(b) $R(\uparrow)$: $R + 20 = 5g$
$R = 5g - 20 = 29$N

(c) $R(\uparrow)$: $R + 49 = 5g$
$R = 5g - 49 = 0$ N
So the mass is on the point of lifting off the table

(d) $R(\uparrow)$: $R + 50 = 5g$
$R = 5g - 50 = -1$ N
But $R \geq 0$ so the mass is no longer in contact with the surface.
Therefore, we need to use $F = ma$ rather than resolving
$F = ma(\uparrow)$: $50 - 5g = 5a$ so
$a = 0.2$ m/s^2
So the mass is accelerating upwards with acceleration 0.2 m/s^2

(e) $R(\uparrow)$: $R = 5g + 20 = 69$ N

Now the 20 N is acting in the direction of the weight and so the normal reaction force is increased.

E.g. 3 A crate of mass 50 kg, resting on the ground, has a vertical cable attached to it. Find the normal reaction force between the crate and the ground when the tension in the cable is:

(a) 0 N

(b) 300 N

(c) 600 N.

Consider a person in a lift

Imagine standing in a lift. When the lift is ***stationary*** or moving at a ***constant speed*** (e.g. half-way between floors), then the normal contact force on your feet is equal to your weight.

Think of the sensation on your feet in a lift in the following scenarios. Is the force on your feet greater than or less than your weight?

Accelerating up (sets off to go up):	$R > mg$ (normal contact > weight)
Accelerating down (sets off to go down):	$R < mg$ (normal contact < weight)
Decelerating up (coming to stop at the floor above):	$R < mg$ (normal contact < weight)
Decelerating down (coming to stop at the floor below):	$R > mg$ (normal contact > weight)

N.B. The normal reaction force is larger when a lift is accelerating upwards or decelerating downwards than when it is accelerating downwards.

E.g. 4 A mass of 40 kg rests on a platform. The platform is subjected to accelerations of 7m/s^2 upwards and downwards. Find:

(a) the normal contact force when the platform is not accelerating

(b) the normal contact force when the platform is accelerating upwards

(c) the normal contact force when the platform is accelerating downwards.

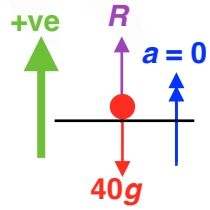
Working:

(a) $F = ma(\uparrow)$: $R - 40g = 0$

$R = 40g$

$R = 392$

The normal contact force is 392 N



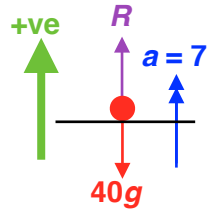
(b) Since the platform is accelerating upwards, take "up" to be the positive direction.

$F = ma(\uparrow)$: $R - 40g = 40 \times 7$

$R = 40g + 280$

$R = 672$

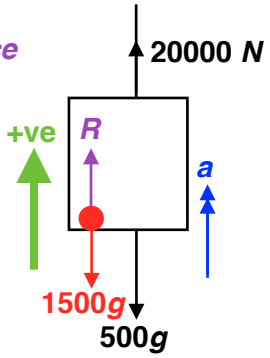
The normal contact force is 672 N



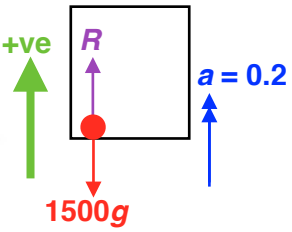
(c)

E.g. 5 A mass 1500 kg is placed in a cage of mass 500 kg, which is raised vertically from a crane. The tension in the cable attached to the cage is 20000 N. Find:
(a) the acceleration of the cage and its direction, and
(b) the contact force between the mass and the cage.

Working: (a) ***The complete diagram is to the right but to answer (a) we ignore the normal reaction force R, as this does not affect the tension. Assume the positive direction is upwards.***



(b) ***To calculate the normal reaction force, we ignore the tension and the weight of the cage as they do not affect it. Assume the positive direction is upwards.***



Video: Normal contact force
Video: Lift problems

Lift problems EQ

Solutions to Starter and E.g.s

Exercise
p514 22B Qu (1iabd), 2i, 3-9

Summary
Normal reaction or normal contact force, R, act ***at right angles to the surface of contact***.

If ***no other forces*** are acting and there is no acceleration, the normal contact force, ***R, equals the weight*** of the object.

N.B. $R \geq 0$ — if you resolve and find R is negative, it means the object is no longer in contact with the surface.
When $R = 0$, the object is just about to lift off the surface
The normal reaction force is larger when a lift is accelerating upwards or decelerating downwards than when it is accelerating downwards.