Normal Reaction Force

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:

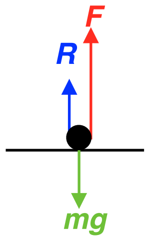
(a) pull up on the book
(b) push down on the book?

Working: (a) Normal contact force decreases i.e. normal contact force $<$ weight

(b) Normal contact force increases i.e. normal contact force $>$ weight

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

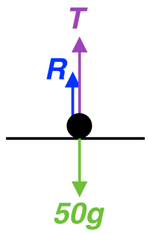
(b) $R(\uparrow)$: $R + 20 = 5g$
$R = 5g - 20 = 29$N

(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/s²
So the mass is accelerating upwards with acceleration 0.2 m/s²

(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.

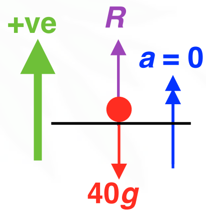


Working: (a) $R(\uparrow)$: $T + R = 50g$
Since $T = 0$: $R = 50g$
$R = 490$ N

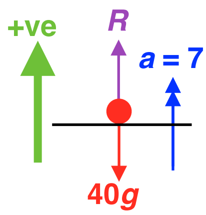
(b) $R(\uparrow)$: $300 + R = 50g$
$R = 50g - 300$
$R = 190$ N

(c) $R(\uparrow)$: $600 + R = 50g$
$R = 50g - 600$
But $50g < 600$ so this would give a negative value for R, which is not possible since $R \geq 0$.
Therefore, $R = 0$ N and the crate will have lifted off the ground.
$F = ma(\uparrow)$: $600 - 50g = 50a$
$a = 2.2$
The crate accelerates at 2.2 m/s^2.

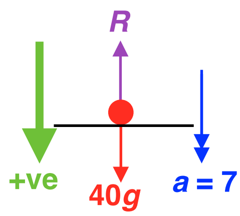
E.g. 4 A mass of 40 kg rests on a platform. The platform is subjected to accelerations of 7m/s^2 upwards and downwards. Find:
(a) the normal contact force when the platform is not accelerating
(b) the normal contact force when the platform is accelerating upwards
(c) the normal contact force when the 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) Since the platform is accelerating downwards, take "down" to be the positive direction.
$F = ma(\uparrow)$: $40g - R = 40 \times 7$
$R = 40g - 280$
$R = 112$
The normal contact force is 112 N

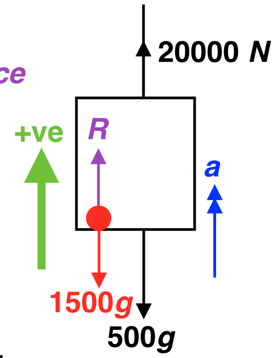
E.g. 5 A mass 1500 kg is placed in a cage of mass 500 kg, which is raised vertically from a crane. The tension in the cable attached to the cage is 20000 N. Find:

(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.



$F = ma(\uparrow)$:

$$20000 - 1500g - 500g = (1500 + 500)a$$

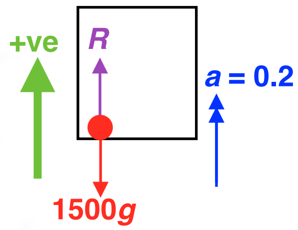
$$a = \frac{20000 - 1500g - 500g}{1500 + 500}$$

$$a = 0.2$$

The acceleration of the cage is 0.2 m/s², 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.



$F = ma(\uparrow)$:

$$R - 1500g = 1500 \times 0.2$$

$$R = 1500 \times 0.2 + 1500g$$

$$R = 15000 \text{ N}$$

The contact force between the mass and the cage is 15000 N

Video: Normal contact force

Video: Lift problems

Lift problems EQ

Solutions to Starter and E.g.s

Exercise

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