Section 2.13: The Normal Force

Recall: Newton's Third Law of Motion deals with action-reaction forces which involves two objects. An **initiating** body creates the action force and the **receiving** body creates the reaction force. When the body receiving the action force is a surface, the **reaction force of the surface pushing back** is called the **normal force**.

Ex. If you are pushing down on the floor, the reaction force is the floor is pushing up on you. This is the normal force. **The normal force is always perpendicular to the surface.**

Example 1: David's mass is 40.0 kg and he is sitting on a box. What is the normal force acting on David?

$m = 40.0\,kg$

$a = 0$

$F_{Net} = 0$

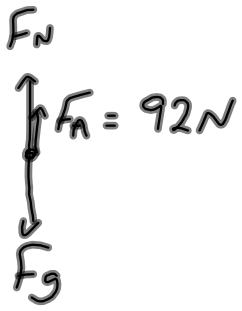
$F_N = F_g$

$= mg$

$= (40\,kg)(9.8\,m/s^2)$

$= 392\,N$

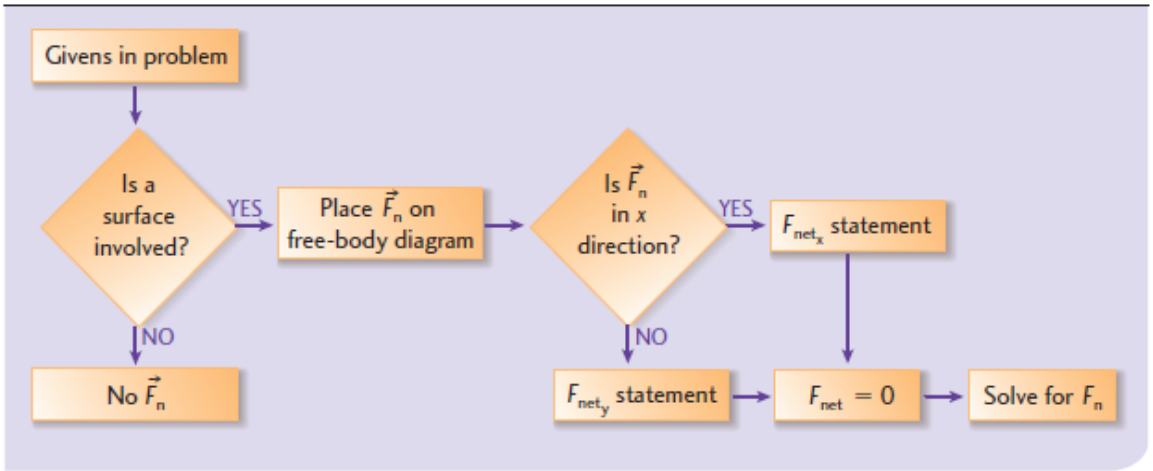
Example 2: A friend is trying to lift David using a hoist that exerts a force of 92 N. Find the normal force on David.



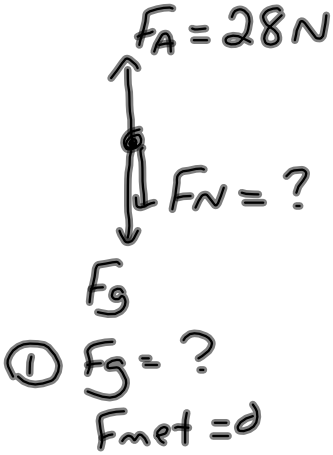
① $F_g = mg$
$= (40kg)(9.8 m/s^2)$
$= 392N$

② $F_{net} = F_N + F_A - F_g$
$0 = F_N + 92N - 392N$
$300N = F_N$

Finding the Normal Force



Example 3: You are holding a light fixture of mass 1.5 kg with a force of 28 N against the ceiling. What is the normal force on the light?



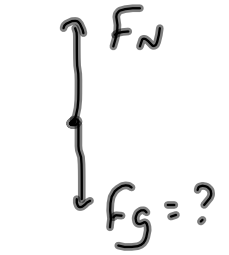
① $F_g = mg$
$= (1.5kg)(9.8 m/s^2)$
$= 14.7 N$

② $F_{net} = F_A + F_N - F_g$
$0 = 28N + F_N - 14.7N$
$-13N = F_N$

When you are standing on a bathroom scale, you exert a force down on the scale (Fg) and the scale exerts an upward force on you (F_N). It is this force – F_N – that gives you the reading on the scale. If you were standing on a bathroom scale while riding in an elevator, F_N will give you your "apparent weight". Your apparent weight will depend on the velocity or acceleration of the elevator.

Example 4: For the following cases, calculate the reading on the bathroom scale (i.e. the apparent weight or the normal force) if the mass of the person is 1.00×10^2 kg.

A) The elevator is at rest.

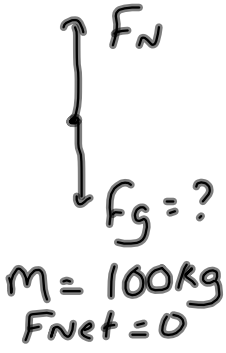


① $F_g = mg = (100\,kg)(9.8\,m/s^2)$
$= 980\,N$

② $F_{net} = F_N - F_g$
$0 = F_N - 980\,N$
$980\,N = F_N$

* When the elevator is at rest $F_N = F_g$.
(Apparent Weight = Actual Weight)

B) The elevator is moving downward at a constant speed of 3.0 m/s.



Since elevator is moving at a constant speed $F_{net} = 0$ which means

$F_N = F_g = 980\,N$.

C) The elevator is accelerating upward at 3.0 m/s^2.

m = 100kg
a = 3.0m/s^2
Fg = ?
Fnet = ?

① $F_g = 980N$

② $F_{net} = ma$
$= (100kg)(3.0m/s^2)$
$= 300N$

③ $F_{net} = F_N - F_g$
$300N = F_N - 980N$
$1280N = F_N$

* When you are accelerating upward, Fnet is upward, which means that $F_N > F_g$. As a result, your apparent weight is greater than your actual weight.

D) The elevator is accelerating downward at 3.0 m/s^2.

m = 100kg
a = -3.0m/s^2
Fg = ?
Fnet = ?

① $F_g = 980N$

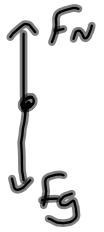
② $F_{net} = -300N$

③ $F_{net} = F_N - F_g$
$-300N = F_N - 980N$
$680N = F_N$

* When you are accelerating downward, Fnet is downward which means that $F_g > F_N$ (or $F_N < F_g$)

As a result, your apparent weight is less than your actual weight

E) The cable broke and the elevator is in free fall.



$a = -9.8\ m/s^2$
(free-fall)

① $F_g = 980\ N$

② $F_{net} = ma$
$= (100\ kg)(-9.8\ m/s^2)$
$= -980\ N$

③ $F_{net} = F_N - F_g$
$-980\ N = F_N - 980\ N$
$0 = F_N$

Note: In free-fall, you feel weightless.

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