Physics 20

Unit B: Forces and gravitation

Motion on planes

Inclines and elevators

- An 8.00 kg sled is in a hallway.
- A 70.0 kg rider is in an elevator.
- A 2.50 kg cart is on a 30.0 degree ramp.
- Draw a separate arrow diagram for the sled, the elevator, and the ramp. Air is left out of the arithmetic.

Three surfaces, two weight components

- A level floor keeps one horizontal axis and one vertical axis.
- An elevator keeps upward as positive while the car accelerates.
- An inclined plane splits weight into a parallel component and a perpendicular component.

Key terms

inclined plane

An inclined plane is a flat surface set at an acute angle to the horizontal axis. (theta)

parallel component

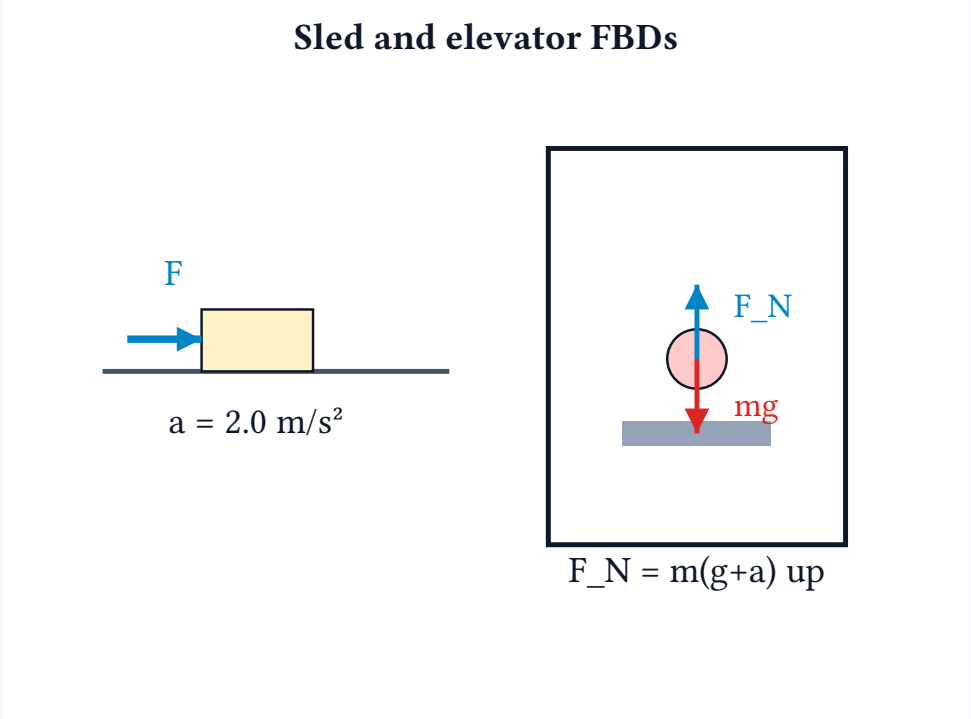
The parallel component of weight is m g sin theta, directed down the incline. Here m is mass, g is 9.81 m/s squared downward, and theta is the angle from the horizontal. (m g sin theta)

perpendicular component

The perpendicular component of weight is m g cos theta, directed into the incline. The same m, g, and theta are the mass, the field strength, and the ramp angle. (m g cos theta)

Hallway arithmetic and the elevator floor

- The hallway sled accelerates at 2.00 m/s squared forward.
- Upward is positive in the elevator, so the normal force is m times the quantity g plus a.
- The hallway sled and the elevator use only the forces on the diagram. Air is left out.

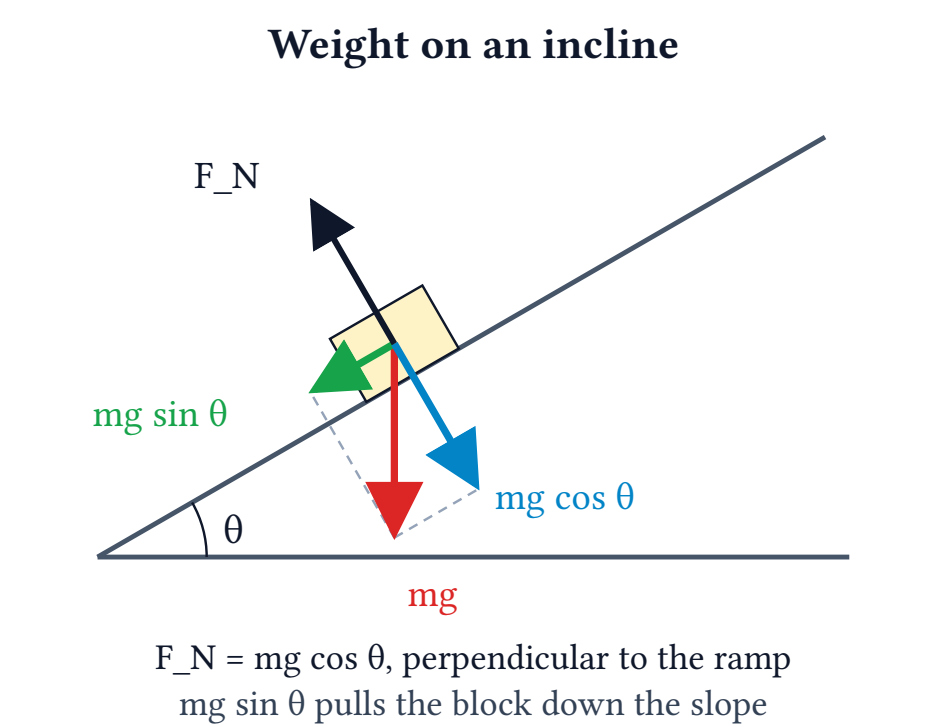


A 30.0 degree cart

- Parallel: (2.50 kg)(9.81)(sin 30) = 12.3 N down the ramp.
- Perpendicular: (2.50 kg)(9.81)(cos 30) = 21.2 N into the ramp.
- Friction free: 12.3 N / 2.50 kg = 4.91 m/s^2 down the ramp.

Weight component into the ramp

- The perpendicular component is m g cos theta into the surface.
- On a friction free incline the normal force matches that perpendicular component.
- Measure the ramp angle from the horizontal, and keep that angle under 90 degrees.



A rider accelerating upward

- A 55.0 kg rider accelerates upward at 1.20 m/s squared.
- Take upward as positive and find the floor’s normal force.
- Compare that force with the rider’s weight.

A 20 degree ramp

- A 4.00 kg crate rests on a friction free ramp at 20 degrees to the horizontal.
- Find the parallel component and the perpendicular component.
- Find the acceleration down the incline.