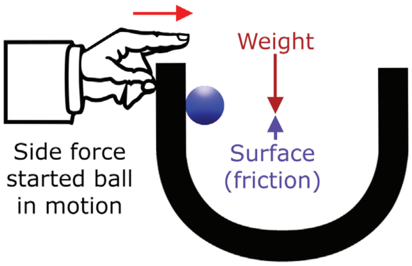
The object in static equilibrium has inertia, and its inertia means it will continue to be motionless. The only way for static equilibrium to be disturbed is for a force to be applied to the object.

No longer in static equilibrium because a side force created a force imbalance (ΣF no longer 0) and started motion

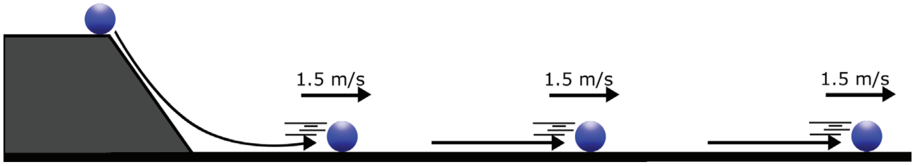


As soon as the left-to-right force is applied to the ball, the ΣF is no longer 0. The ball moves in the direction of the externally applied force (to the right) and static equilibrium is broken. Also, note that the magnitude of the force of the ball's weight is much larger than the force of friction at the point indicated in the ball's descent. This is important because objects always move in the direction of the net force they receive, which, in this case, is "down."

We also look at an object in dynamic equilibrium according to the first law, in its ideal state as described by the first law. As we know, in dynamic equilibrium, the object moves with constant velocity while ΣF is also 0. From the first law standpoint, an object in dynamic equilibrium has inertia and its inertia keeps it moving at constant velocity, forever, unless an external force acts on it.

New graphic

The ball is in dynamic equilibrium since it is moving at constant velocity

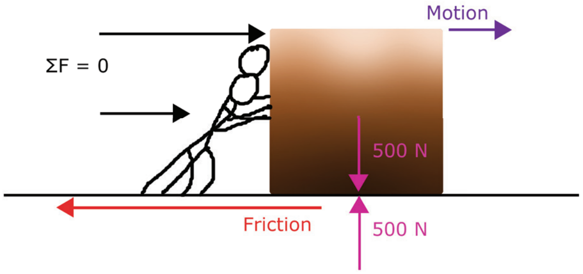


As the ball starts to roll down the ramp, it is not yet in dynamic equilibrium because it speeds up down the ramp, which means that the net force on it is not zero. In the "ideal" world, once the ball hits the floor, though, it is in dynamic equilibrium. It continues to roll "straight" (the direction) at a speed of 1.5 m/s until an external force acts on it. The Newtonian/Galilean way to look at an object in motion allows us to appreciate the effect of an external force on an object. In the ideal state—one where there are no external forces acting on a body at rest or in motion—the object maintains that condition. As soon as an external force comes into play on that body, though, dynamic equilibrium is disrupted, and the object will be moved in the direction of the external force.

In the real world, to maintain dynamic equilibrium requires a constant input of force (meaning an input of energy), as we saw in Chapter 5 when the man pushed the cart, or the stick men pushed the box, to maintain dynamic equilibrium. Since external forces act on objects all the time, motion means friction and friction opposes the motion; therefore, a constant force is necessary to offset friction if dynamic equilibrium is to be maintained. When an object moves at constant velocity, the force moving it in the direction it is moving is equal in magnitude to the friction force, but since they are in exact opposite directions, the net force is 0, which allows dynamic equilibrium to be maintained.

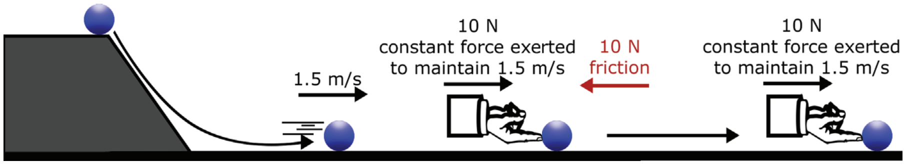
In the real world, the constant input of energy (here from the two stick men pushing the box at constant speed and in a constant direction) is what allows dynamic equilibrium to be maintained

New graphic



As another example of the observed differences between the real world and the ideal Galilean world, a force of 10 N exerted to the right on the ball below matches the 10 N force of friction to the left; therefore, the ΣF is 0 and it moves at a constant 1.5 m/s due to the externally applied force of 10 N. The ball continues to move with constant velocity in the same direction; it is in dynamic equilibrium. As soon as the external force is removed, friction becomes unopposed and the ball slows and stops.

In the real world, an external force is required to maintain dynamic equilibrium



6.5 MASS AND WEIGHT

Any discussion of inertia is not complete without a discussion of mass, because the two are inextricably linked—mass is inertia and inertia is mass. But, before we talk about the relationship between mass and inertia further, we should look at mass and weight a little closer. The reason that we will talk about this in such depth is that the distinction between weight and mass can be very confusing. It shouldn't be, but it is because the two measurements are frequently blurred together. What isn't confusing is that the SI unit of weight measurement is newtons and of mass measurement is kilograms, but what is confusing is that even in scientific papers, we often report "weights" in kilograms when technically they should be reported in newtons. There is a good reason that weights are reported in mass units of kilograms instead of weight units of newtons, and it is instructive to understand the logic behind why that is.

Mass is the quantity of matter an object contains, reported in grams, or units thereof, and **weight** is the gravitational force acting on an object, reported in newtons, or units thereof. The way I described it last chapter is that weight is created by gravity pulling on an object's mass. The more mass an object has, the more matter gravity has to pull on, so the more it weighs. The official standard of a kilogram—how we calibrate the measurement of the kilogram—is with something called the "kilogram mass standard," which is a chunk of metal housed in France. There are lots of other kilogram mass standards that were calibrated against that one in France, though, all over the world.