Mechanical Advantage

In its simplest form, a lever is a rigid bar that rotates about a fixed point (the fulcrum). The lever is an example of a simple machine that can be used to amplify a force (Fig. 8.29). The **mechanical advantage (MA)** is defined as the ratio of the output force (load) to the applied force:

$$\text{MA} = \frac{\text{load}}{\text{applied force}}$$

For an ideal lever, by using the fulcrum as the axis of rotation and setting the net torque on the lever equal to zero, we find that the mechanical advantage is equal to the ratio of the lever arms:

$$\text{MA} = \frac{\text{lever arm of applied force}}{\text{lever arm of load}}$$

The force amplification comes with a trade-off: the applied force must move through a larger distance than the load.

$$\text{MA} = \frac{\text{displacement of applied force}}{\text{displacement of load}}$$

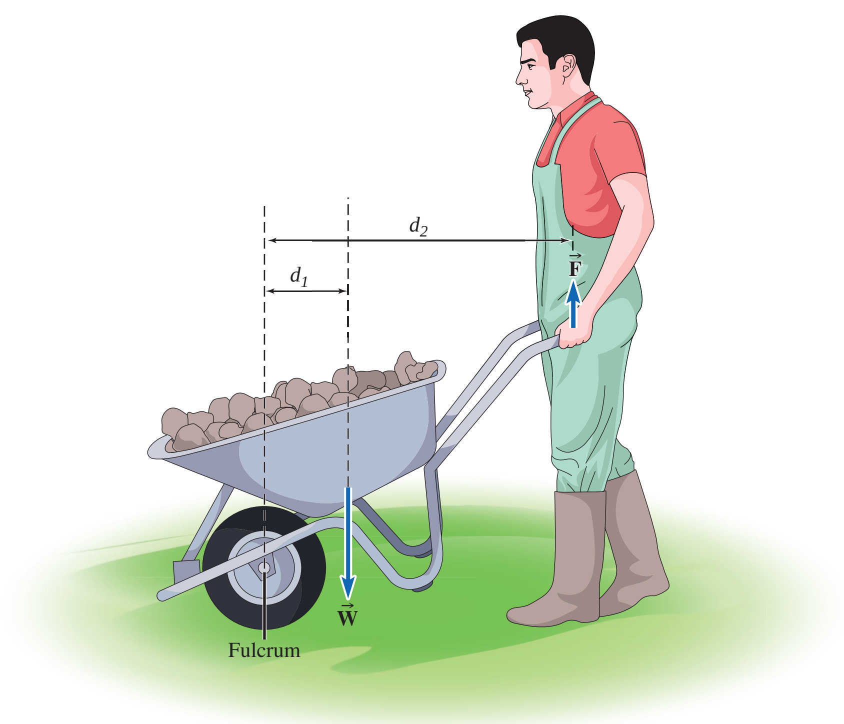

Figure 8.29 A wheelbarrow uses a lever to make it easier to lift heavy loads. The mechanical advantage is the ratio of the output force (load) to the applied force. For the wheelbarrow, the load is the weight of the wheelbarrow contents (W) and the applied force (F) is exerted by the gardener on the handles. If the rotational inertia of the lever itself is negligible, the net torque on the lever has to be zero. Using the fulcrum as the axis of rotation, we have $\Sigma\tau = Fd_2 - Wd_1 = 0$, where d_1 and d_2 are the lever arms of the applied force an load, respectively. The mechanical advantage is:

$\text{MA} = (\text{load})/(\text{applied force}) = W/F = d_2/d_1$.