25.2: Wheel and Axle

A wheel and axle consists of a large wheel rigidly attached to a smaller axle. The resistive force is attached to the axle, and the applied effort force is attached to the larger wheel. Then the distance traveled by the resistive force is $2\pi r_a$, where r_a is the axle radius. The distance through which the effort force is applied is $2\pi r_w$, where r_w is the wheel radius. (Figure 25.2.1)

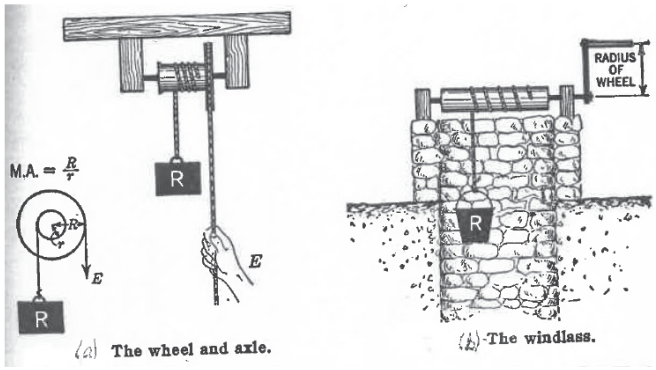

Figure 25.2.1: (a) The wheel and axle. (b) The windlass, another type of wheel and axle. Here R is the resistance (resistive force) and E is the effort (effort force). (Ref. [17])

The input and output work are

$$W_i = F_E 2\pi r_w \tag{25.2.1}$$

$$W_o = F_R 2\pi r_a \tag{25.2.2}$$

In the absence of friction, $W_i = W_o$, so

$$F_E 2\pi r_w = F_R 2\pi r_a \tag{25.2.3}$$

The mechanical advantage is then

$$M.A. = \frac{F_R}{F_E} = \frac{2\pi r_w}{2\pi r_a} \tag{25.2.4}$$

or

$$M.A. = \frac{r_w}{r_a} \tag{25.2.5}$$