$$P_{in} = T_{in}\omega_{in}$$
$$P_{out} = T_{out}\omega_{out} \tag{6.12e}$$

and:

$$P_{out} = P_{in}$$
$$T_{out}\omega_{out} = T_{in}\omega_{in}$$
$$\frac{T_{out}}{T_{in}} = \frac{\omega_{in}}{\omega_{out}} \tag{6.12f}$$

Note that the **torque ratio** ($m_T = T_{out}/T_{in}$) is the inverse of the angular velocity ratio.

Mechanical advantage (m_A) can be defined as:

$$m_A = \frac{F_{out}}{F_{in}} \tag{6.13a}$$

Assuming that the input and output forces are applied at some radii r_{in} and r_{out}, perpendicular to their respective force vectors,

$$F_{out} = \frac{T_{out}}{r_{out}}$$
$$F_{in} = \frac{T_{in}}{r_{in}} \tag{6.13b}$$

substituting equations 6.13b in 6.13a gives an expression in terms of torque.

$$m_A = \left(\frac{T_{out}}{T_{in}}\right)\left(\frac{r_{in}}{r_{out}}\right) \tag{6.13c}$$

Substituting equation 6.12f in 6.13c gives

$$m_A = \left(\frac{\omega_{in}}{\omega_{out}}\right)\left(\frac{r_{in}}{r_{out}}\right) \tag{6.13d}$$

and substituting equation 6.11f (p. 302) gives

$$m_A = \left(\frac{O_4 B \sin\mu}{O_2 A \sin\nu}\right)\left(\frac{r_{in}}{r_{out}}\right) \tag{6.13e}$$

See Figure 6-11 and compare equation 6.13e to equation 6.11f (p. 302) and its discussion under **angular velocity ratio** (p. 301). Equation 6.13e shows that for any choice of r_{in} and r_{out}, the mechanical advantage responds to changes in angles ν and μ in opposite fashion to that of the angular velocity ratio. If the transmission angle μ goes to zero (which we don't want it to do), the mechanical advantage also goes to zero regardless of the amount of input force or torque applied. But, when angle ν goes to zero (which it can and does, twice per cycle in a Grashof linkage), the mechanical advantage becomes infinite! This is the principle of a rock-crusher mechanism as shown in Figure 6-11. A quite moderate force applied to link 2 can generate a huge force on link 4 to crush the rock. Of course, we cannot expect to achieve the theoretical output of infinite force or torque magnitude, as the strengths of the links and joints will limit the maximum forces and torques obtainable. Another common example of a linkage that takes advantage of