

## Examples

Ideal asymmetric two-port junction elements, gyrators and transformers, describe the transmission or transduction of power, one of the most fundamental aspects of all machinery. An abundant variety of devices that may be modeled using transformers or gyrators.

### Rotation to Translation

Almost all mechanisms involve some relation between rotation and translation, as the following examples illustrate.

#### *Pivoted Lever Arm*

One of the simplest examples is the pivoted lever arm shown in figure 5.7. Rotation of the shaft results in motion of the end of the arm. Assuming the arm is rigid and the pivot constrains it to motion about a fixed axis, a relation between displacements (the angle of the arm,  $\theta$ , and the horizontal position of its end,  $x$ ) may be derived from simple geometry.

$$x = l \sin(\theta) \quad (5.19)$$

A relation between flows (the angular speed of the arm,  $\omega$ , and the horizontal linear velocity of the end,  $v$ ) may be obtained by differentiating with respect to time.

$$v = l \cos(\theta) \omega \quad (5.20)$$

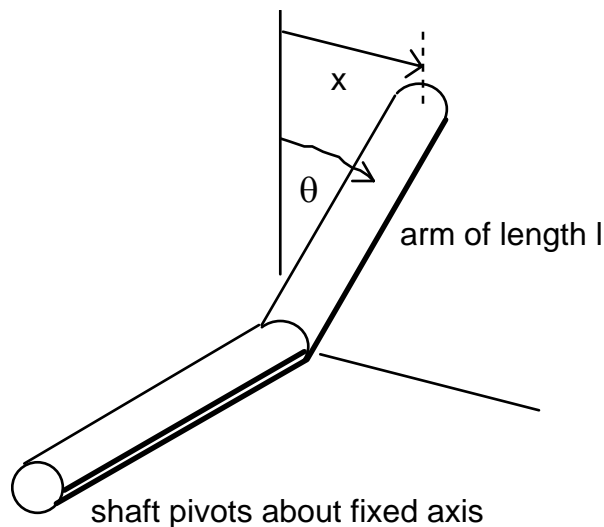


Figure 5.7: Diagram of a simple rotation-to-translation transformer.

This is one of the equations of a transformer relating the translational and rotational domains. The other equation relates horizontal force,  $F$ , at the end to moment,  $\mu$ , about the axis. The moment arm is the perpendicular distance from the end to the axis.

$$\mu = l \cos(\theta) F \quad (5.21)$$

Equations 5.20 and 5.21 define a modulated transformer (e.g figure 5.6) with a single parameter  $T = 1 \cos(\theta)$  modulated, in this case, by the angle  $\theta$ . As required by the definition of a pure transformer, power in equals power out ( $Fv = \mu\omega$ ). Note that this fundamentally stems from the fact that the same geometric quantity, the perpendicular distance from the end to the axis, is the parameter in both equations.

### *Scotch Yoke*

When the shaft in figure 5.7 rotates, the vertical position of the end of the arm also changes, a fact ignored in equation 5.19. It may seem that an important part of the mechanical behavior has been ignored, but it should be recognized that there are numerous contrivances by which the vertical position may be made irrelevant. One example is the Scotch Yoke shown in figure 5.8.

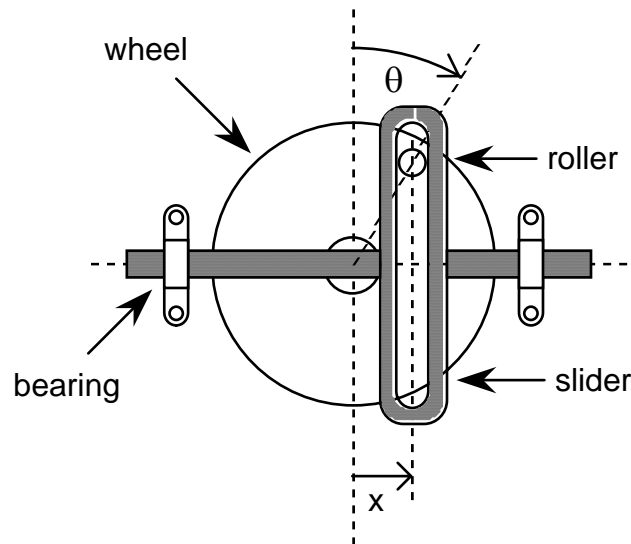


Figure 5.8: Another rotation-to-translation transformer: a Scotch Yoke.