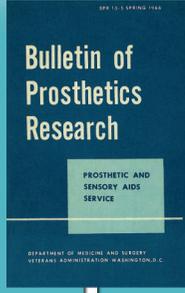
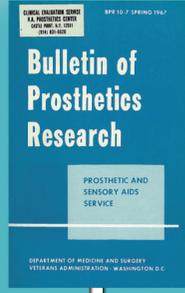


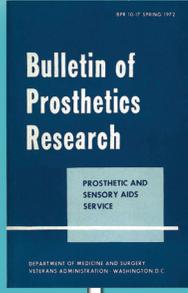
1964



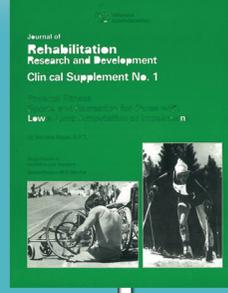
1966



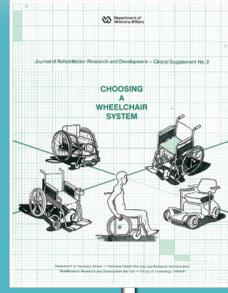
1967



1972



1985



1990



1994

# THEN & NOW

2001

2003

2004

2005

2006

2009

2013



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## PROPERTIES OF FLUID FLOW APPLIED TO ABOVE-KNEE PROSTHESES

ANTHONY STAROS, MSME; EUGENE F. MURPHY, PHD

An understanding of some of the key principles of fluid mechanics is necessary for full appreciation and wise prescription from the armamentarium of hydraulic and pneumatic systems which are increasingly becoming available in prosthetics. A review of the differences between mechanical friction and fluid friction will help to define the underlying principles of these fluid-controlled mechanisms. (Numerous textbooks are available for the serious student.) Then the internal structure and the possible adjustments of some specific models will be described briefly. Very shortly, the journal *Artificial Limbs* will devote a special issue to a comprehensive and detailed discussion of all the mechanisms which were studied in detail by an ad hoc committee appointed by the Committee on Prosthetics Research and Development of the National Academy of Sciences—National Research Council.

### MECHANICAL FRICTION

Mechanical static friction is the force which resists any external force that tends to cause the sliding of one body over another with which it is in contact, as in Figure 1. It eventually reaches a maximum at which sliding is imminent. This limiting static frictional force is directly proportional to the perpendicular or “nor-

mal” force pressing the two bodies together. It is possible to determine limiting static mechanical friction by measuring the force that must be used to overcome the friction with a given clamping force. Thus, the ratio of the frictional force to the perpendicular force pressing the two bodies together gives the static coefficient of friction,  $f = F/N$ , which is related to the materials involved. Thus the static coefficient of friction is constant for any two particular surfaces, e.g., approximately 0.15 for steel on steel and 0.50 for leather on iron. By means of tables of such coefficients it is possible to estimate in advance what the friction would be between two bodies, such as a metal bar on a wooden socket.

The coefficient of friction between dry surfaces depends considerably on the nature of the surfaces. (The coefficient also is affected by their roughnesses, such as those of metals machined with a coarse or a fine tool, polished, or allowed to rust. The coefficient of friction between wooden blocks depends on the relative direction of the grains of the two blocks to each other and to the direction of potential motion.) Also, the value of static friction may be affected by the length of time the bodies are in contact. Thus the published tables of co-

efficients often supply ranges rather than precise values.

The coefficient of friction for the same two surfaces will differ, however, depending upon whether the bodies are stationary or in motion. To start a body sliding over another requires a certain force, but to keep the same body moving at a constant speed requires only a lower force. Indeed, starting friction (also called limiting static friction or “stiction”) is always greater than sliding (kinetic) friction. Thus the same two materials, without changes in rubbing surfaces, will have two different coefficients of friction: (1) a coefficient of starting friction and (2) a lower coefficient of sliding friction. Once in motion, however, the coefficient of kinetic friction remains constant even though the velocity may change, a major point in prosthetics.

The lower value of sliding or kinetic friction is important, even crucial, in many aspects of everyday life. Skidding of an automobile tire on the pavement or of a crutch tip on the sidewalk begins when the limiting static friction is exceeded, but becomes even worse as the frictional resistance drops to the sliding or kinetic value.

To continue reading, please visit <http://www.rehab.research.va.gov/jour/64/1/1/40.pdf>



## SWING PHASE CONTROL—FROM FLUID MECHANICS TO MICROPROCESSORS

STEVEN A. GARD, PHD

The topic matter of “Properties of fluid flow applied to above-knee prostheses” is as relevant to the design and operation of prosthetic knees today as it was 50 years ago when it was published in *JRRD* (i.e., *Bulletin of Prosthetics Research*). The property of swing phase control—damping that is provided in some prosthetic knee units to modulate the period of swing—is important for enabling above-knee prosthesis users to walk at variable speeds. The article by Staros and Murphy is a comprehensive primer on fluid dynamics for clinicians who would prescribe, fit, and evaluate mechanical fluid-controlled knee units, covering important principles on how different hydraulic and pneumatic mechanisms operate. At the time, skilled clinicians were required to be mindful of numerous details about fluid-controlled knee units in order to appropriately adjust and evaluate the components and provide prosthesis users with optimal function.

Today, with the advent of microprocessor-controlled prosthetic knee units that are designed to modulate swing phase control, much of that burden is assumed by the knee unit itself. While prosthetists are still required to know fundamental principles about fluid-controlled prosthetic components to perform successful fittings, confidence can now be placed in the “smart” processing units for ongoing fine-tuning of the systems while the user walks with them. Operationally, the computer-controlled knee units today are similar to those mechanical units from decades ago. However, even broader ranges of walking speeds can be attained by prosthesis users walking with these knee units because of the constant monitoring and adjustments to swing phase control. Additionally, more sophisticated functions can now be imparted by microprocessor-controlled knee units, such as improved stumble control during swing phase. Today, numerous publications attest to the superiority of microprocessor-controlled knees compared with their mechanical counterparts. More importantly, these advancements in technology over the past 50 years have greatly enhanced patient care, enabling prosthetists and other caregivers to focus less on the intricacies of the prosthetic componentry and more on the rehabilitation and well-being of the prosthesis user.

