In the early days of helmet testing, BSI, Snell and ASA, the forerunner of ANSI, all allowed the swing away device instead of, or as an alternate to, the guided fall device. The swing away device positioned the helmet and head form on an arm in the path of a guided impactor which fell to strike the helmet at a specified velocity. Upon striking, some of the momentum of the impactor was transmitted to the helmet and head form causing them and the arm to pivot out of the way. Although the equipment differs, the swing-away and guided fall devices are similar if you consider the impactor element in the swing away device comparable to the massive reaction block supporting the impact anvil in the guided fall device and the head form and arm elements comparable to the head form and guidance elements. The fact that, for the swing away, the impactor strikes the helmet while in guided fall, the helmet strikes the anvil is merely a matter of perspective.

Before attempting any analysis, it is probably best to dispose of one complicating factor: the mass of the helmet. The simplest assumption is that the helmet matches speeds with the striking surface, either the impactor or the anvil, before the interaction between the helmet and the head form begins. Effectively, this leaves just two masses to consider, the mass of the head form and the combined mass of the helmet and the striking surface. Since the effective mass of the anvil as it rests on the reaction block is, for all purposes, infinite, there's not much need to consider helmet mass at all but, for the swing away device, the impact velocity of the striker will be reduced slightly by the momentum exchange just before the head form interaction begins.

During the interaction, the helmet wall applies forces to both the impact surface and the head form. The accelerations of the two objects are:

$$\ddot{x}_1 = -\frac{1}{M_1} F(x_1 - x_2)$$

$$\ddot{x}_2 = \frac{1}{M_2} F(x_1 - x_2)$$

The symbols x and M refer to position and mass and the subscripts 1 and 2 refer to the head form and striking surface respectively. F is the force exerted by the helmet wall as it is crushed between the head form and the striking surface and it is assumed to be solely a function of the distance between the head form and the striking surface. The difference between these two equations is:

$$(\ddot{x}_1 - \ddot{x}_2) = -\left(\frac{M_1 + M_2}{M_1 M_2}\right) F(x_2 - x_2)$$

Let

$$u = x_1 - x_2$$

$$\tau = \gamma t$$

Now

$$\frac{d^2u}{d\tau^2} = \gamma^2 \ddot{u} = -\gamma^2 \left(\frac{M_1 + M_2}{M_1 M_2}\right) F(u)$$

Set

$$\gamma = \sqrt{\left( \frac{M_1 M_2}{M_1 + M_2} \right)}$$

Now

$$\frac{d^2 u}{d\tau^2} = -F(u)$$

Since all the expressions for guided fall and swing-away impact reduce to this form, once the response of a helmet is known to an impact on any of them, the results for a comparable impact on any other can be easily inferred. All that is necessary is that the initial value of u and its first derivative with respect to $\tau$ be the same. In particular, the acceleration time history of the head form need only be scaled along the acceleration axis by the ratio of the head form masses and along the time axis by the ratio of the values of $\gamma$. The critical assumption, of course, is that there are no velocity sensitive components in the crush response of the helmet wall. This assumption is implicit in the structure of the first equations in the development.

$A' = \frac{M_1}{M_1'} A$ Acceleration axis scaling.

$t' = \frac{\gamma}{\gamma'} t$ Time axis scaling.

$V_0' = \frac{\gamma'}{\gamma} V_0$ Comparable impact velocity expression.

The ASA 1967 standard called for the same head form mass for both swing away and guided fall testing so that no acceleration scaling was necessary to compare test results. They also specified impact velocities which came close to matching the ratio specified in the equation just above. However, they did not take any of the timing differences into account in the duration criteria. The system specifications suggest that the guided fall durations would be about 33% longer than those for the swing away. Since the specified impact severity for the swing away device was slightly lower than the value implied by the specification for guided fall, though, this 33% figure probably underestimates what would have been observed in testing. Unfortunately, most everyone at that time was testing with swing away devices so no one realized the disparity. Furthermore, it is probably quite likely that the time duration criteria were prescribed on the basis of swing away test results. Since the engineers of that time would have chosen time duration criteria according to the performance of helmets in the market with only a modest tolerance for quality control, it should come as no surprise that many of the same helmets which met the ASA standard in 1967 began to fail in 1971 when ANSI revised the standard and eliminated the swing away test option. ANSI corrected the time duration oversight in 1973 and increased the time durations allowed by 50% but, in the mean time, the United States Federal Government had begun work on Federal Motor Vehicle Safety Standard 218 (FMVSS 218) using as a basis the flawed ANSI Z90-1971 standard with the short, swing-away time duration criteria. They refused to incorporate the corrections published by ANSI in 1973, perhaps because they planned, instead, to replace the time duration and peak acceleration criteria with the Head Injury Criteria (HIC) which was the subject of another government standard, FMVSS 208. But this replacement never took place; instead, the erroneous time duration criteria from ASA Z90-1967 and from ANSI Z90-1971 persist in FMVSS 218 to this day.