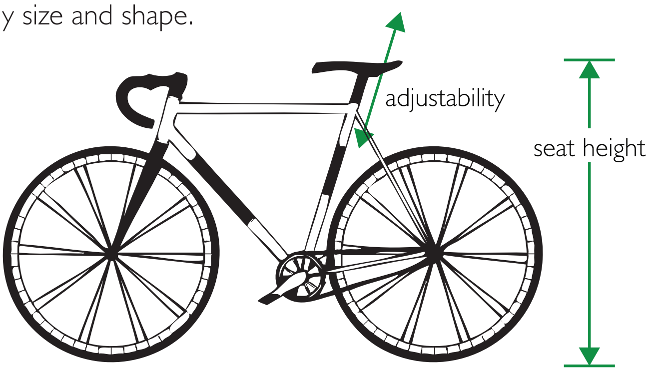
UNIVERSAL DESIGN

DESIGNING FOR BODY SIZE AND SHAPE

Accommodation

Users that are able to interact with a design in the intended manner are said to be **accommodated**. Those for whom the design is uncomfortable, unsafe, or are otherwise unable to achieve the desired performance are said to be **disaccommodated**. One goal of Universal Design is to accommodate users regardless of body size and shape.



ADJUSTABILITY

Incorporating adjustability into a design is one method of accounting for body size and shape. For example, a bicycle might have an adjustable seat to ensure a certain level of performance regardless of user leg length. The amount of adjustability is usually determined by identifying the relevant anthropometric measure and quantifying the range in that measure exhibited by the target user population. Reviewing best practices (e.g., talking to professionals in a bicycle shop) or conducting a user study can provide insight into how to interpret the data for design.

High levels of accommodation can be difficult to achieve with adjustability

A small amount of adjustability can markedly improve accommodation. But higher levels of accommodation—including universal design—can require much more adjustability. For measures that are approximately normally distributed (such as leg length), there are fewer individuals in the tails of the distribution. Consequently, accounting for 52mm of variability would accommodate the central 50% of leg lengths in a sample population, but an additional 69mm of variability accounts for the next 40% (90% total). The examples here use the min and max values, but given the long tails in most distributions it can be more practical to use the 1st and 99th percentiles.

Adjustability Example (min and max)

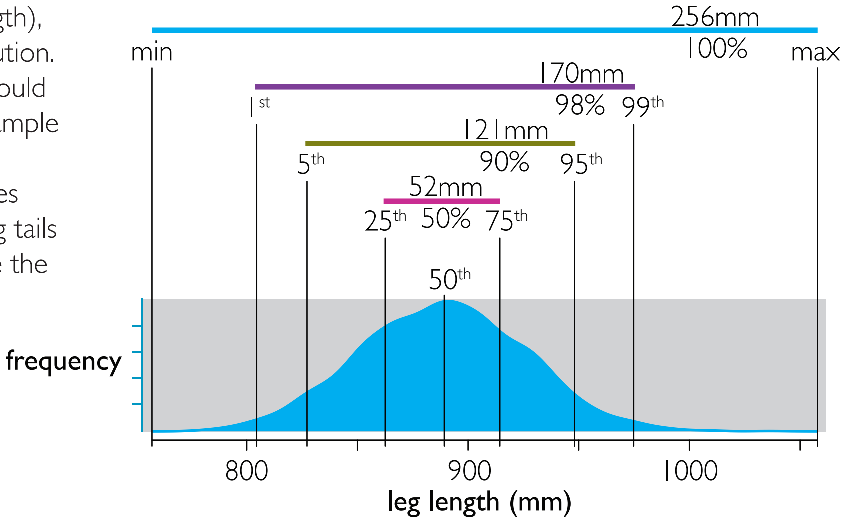
One rule-of-thumb for bicyles is that seat height should be *1.05*leg length*.

Population leg length$_{min}$ = 780mm
Population leg length$_{max}$ = 1036mm
Minimum seat height = 780*1.05 = 819mm
Maximum seat height = 1036*1.05 = 1088mm
Required adjustability = 1088-819 = 269mm

Adjustability Example (1st and 99th percentiles)

One rule-of-thumb for bicyles is that seat height should be *1.05*leg length*.

Population leg length$_{1st}$ = 805mm
Population leg length$_{99th}$ = 975mm
Minimum seat height = 805*1.05 = 845mm
Maximum seat height = 975*1.05 = 1024mm
Required adjustability = 1024-845 = 179mm



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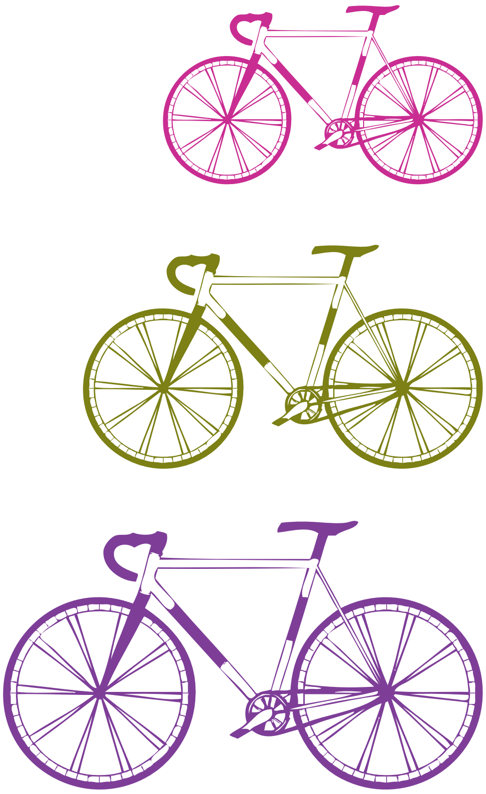
FOR MORE INFORMATION AND ADDITIONAL PRIMERS

Additional information and primers on topics including a *Background*, *Data on Body Size and Shape*, and *Best Practices for User Studies* available at: www.universaldesign.ie

SIZING

An alternative to adjustability is sizing. Shoes, for example, are not adjustable. Instead they come in a number of sizes at fixed intervals. The user selects the size that provides the best functionality (e.g., fit, comfort, performance, safety, etc.). With only a few sizes, users between sizes might not be well accommodated. Increasing the number of sizes can improve accommodation for the entire population, but generally increases cost. As a result, designers must find the relationship between cost and accommodation. Since measures are not uniformly distributed, user demand for sizes near the middle will be greater than demand in the distribution extremes.



Sizing Example

For some number of sizes (n), where i = size (from 1..n) and x = design parameter of interest, the estimated values for each size are determined by:

$$\mathbf{target}_i = x_1 + (x_{99} - x_1)(2i - 1) / 2n$$

For n=3 sizes, using data from *Adjustability* example:

Size 1: $\text{target}_1 = 805 + (975 - 805)(2*1 - 1) / (2*3) = 833\text{mm}$

Size 2: $\text{target}_2 = 805 + (975 - 805)(2*2 - 1) / (2*3) = 890\text{mm}$

Size 3: $\text{target}_3 = 805 + (975 - 805)(2*3 - 1) / (2*3) = 947\text{mm}$

SIZING + ADJUSTABILITY

Sizing can be augmented through the use of adjustability. Adjustability can improve the ability of a size to meet the needs of its intended users. It can also broaden the range of users that the size accommodates. Similarly, adjustability can be improved through sizing. A single size with a large amount of adjustability might be able to accommodate the needs of a target user group, but may be impractical to create due to physical limitations or cost. Using multiple sizes with smaller amounts of adjustability can mitigate these issues while improving important characteristics like fit, performance, and safety.

Sizing + Adjustability Example

The total required adjustability (Δx) is the same as in the adjustability-only example: $\Delta x = x_{upper} - x_{lower}$

The adjustability per size (Δx_i), centered at each size target is: $\Delta x_i = \Delta x / n$

For some number of sizes (n), where i = size (from 1..n) the design targets are: $\mathbf{target}_i = x_{lower} + (2i - 1)\Delta x / 2n$

For n=3 sizes,

$\Delta x = 975 - 805 = 170\text{mm}$

Adjustability, $\Delta x_i = 170 / 3 = 57\text{mm}$

Size 1: $\text{target}_1 = 805 + (1)(170) / (2*3) = 833\text{mm}$

Size 2: $\text{target}_2 = 805 + (3)(170) / (2*3) = 890\text{mm}$

Size 3: $\text{target}_3 = 805 + (5)(170) / (2*3) = 947\text{mm}$