



Photo courtesy of Patricia Little.

# Bicycle Operation and Safety

## 3.1 INTRODUCTION

The purpose of this chapter is to provide the designer with a basic understanding of how bicyclists operate and how their vehicle influences that operation. Knowledge of these elements is essential in order to design appropriately for this mode. Due to the bicycle operator's physical exposure and the unique characteristics of their vehicle, bicyclists are susceptible to severe injury in even minor incidents. Understanding bicyclists' operating characteristics is therefore essential to design facilities that minimize the likelihood of injury. This chapter covers the following topics:

- Design Vehicle
- Traffic Principles for Bicyclists
- Causes of Bicycle Crashes

## 3.2 DESIGN VEHICLE

The physical dimensions and operating characteristics of bicyclists vary considerably. Some of this variation is due to differences in types and quality of bicycles, whereas other variations are due to differing abilities of bicyclists. For bikeways that are shared with other transportation modes such as shared use paths, the bicycle may not always be the critical design vehicle for every element of design. For example, most intersections between roads and pathways should be designed for pedestrian crossing speeds as they are the slowest user.

As with motor vehicles, there are multiple types of design bicyclists. Many of the design dimensions for bikeways presented in this guide are based on critical dimensions or characteristics of different types of bicyclists. For example, recumbent and hand bicyclists are the critical user for eye height; however, a bicycle with a trailer might be the critical user when designing a median refuge island at a shared use path-roadway intersection.

This guide therefore presents bikeway design dimensions that accommodate a range of bicyclists and other non-motorized users, as appropriate. Critical physical dimensions for upright adult bicyclists are shown in Figure 3-1. The minimum operating width of 4 ft (1.2 m), sufficient to accommodate forward movement by most bicyclists, is greater than the physical width momentarily occupied by a rider because of natural side-to-side movement that varies with speed, wind, and bicyclist proficiency. Additional operating width may be needed in some situations, such as on steep grades, and the figure does not include shy distances from parallel objects such as railings, tunnel walls, curbs, or parked cars. In some situations where speed differentials between bicyclists and other road users are relatively small, bicyclists may accept smaller shy distances. However this should not be used to justify designs that are narrower than recommended minimums. The operating height of 8.3 ft (2.5 m) can accommodate an adult bicyclist standing upright on the pedals. Other typical dimensions are shown in Figure 3-1 (4).

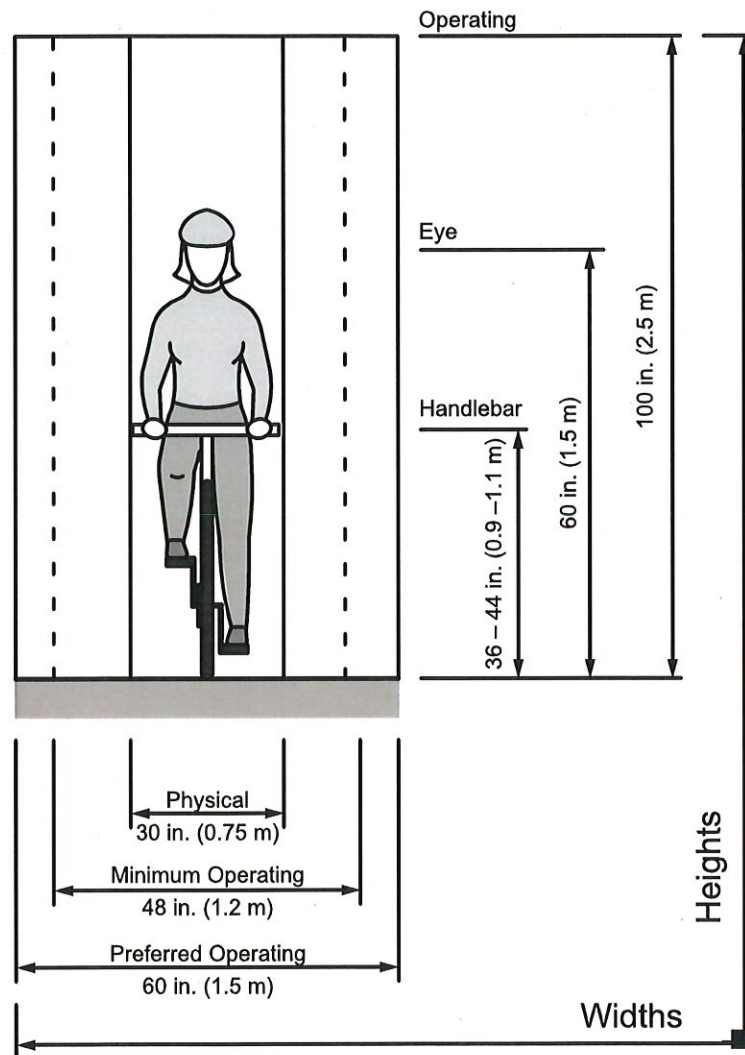


Figure 3-1. Bicyclist Operating Space

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Figure 3-2 contains dimensions for several different types of bicycles including a typical bicycle, recumbent bicycle, tandem bicycle, and a bicycle with a child trailer (A). Table 3-1 lists various key dimensions for typical upright adult bicyclists and typical bicycle configurations, including upright, recumbent, and tandem bicycles; bicycles pulling a child trailer; and inline skaters. Unless otherwise noted, values associated with the 85th percentile of distribution are used to provide a conservative estimate that encompasses most bicyclists (I), (A), (II).

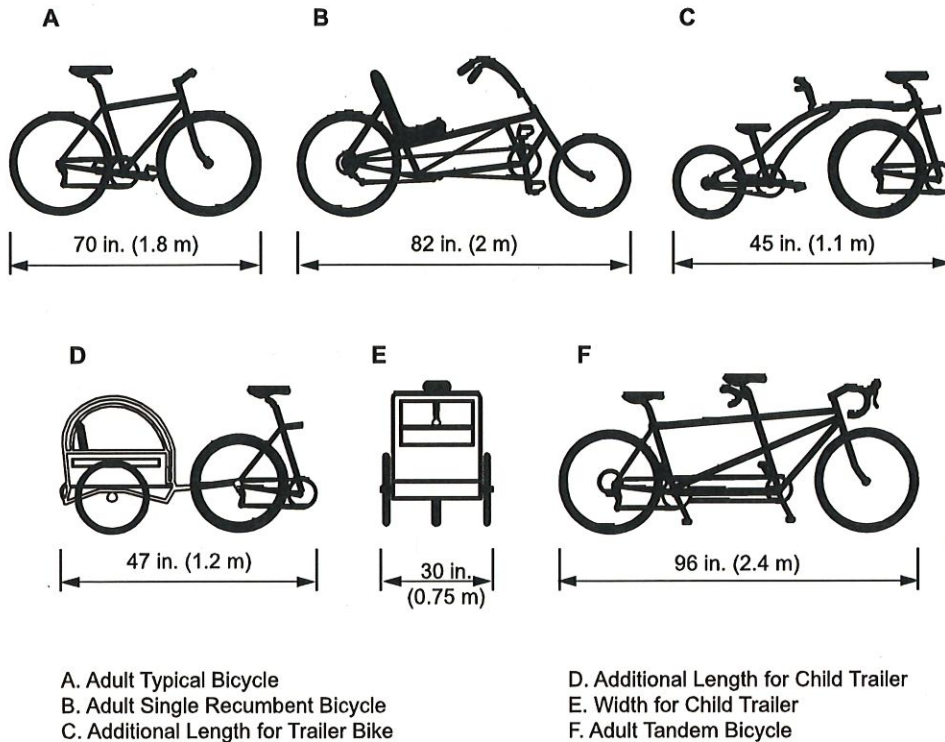


Figure 3-2. Typical Bicycle Dimensions

Table 3-1. Key Dimensions

User Type	Feature	Dimension	
		U.S. Customary	Metric
Typical upright adult bicyclist	Physical width (95th percentile)	30 in.	0.75 m
	Physical length	70 in.	1.8 m
	Physical height of handlebars (typical dimension)	44 in.	1.1 m
	Eye height	60 in.	1.5 m
	Center of gravity (approximate)	33–44 in.	0.8–1.0 m
	Operating width (minimum)	48 in.	1.2 m
	Operating width (preferred)	60 in.	1.5 m
	Operating height (minimum)	100 in.	2.5 m
	Operating height (preferred)	120 in.	3.0 m

Table 3-1. Key Dimensions (continued)

User Type	Feature	Dimension	
		U.S. Customary	Metric
Recumbent bicyclist	Physical length	82 in.	2.2 m
	Eye height	46 in.	1.2 m
Tandem bicyclist	Physical length (typical dimension)	96 in.	2.4 m
Bicyclist with child trailer	Physical width	30 in.	0.75 m
	Physical length	117 in.	3.0 m
Hand bicyclist	Eye height	34 in.	0.9 m
Inline skater	Sweep width	60 in.	1.5 m

As with bicycle dimensions, bicyclist performance can vary considerably based upon operator ability and vehicle design. Table 3-2 lists various performance criteria for typical upright adult bicyclists as well as key performance criteria for other types of bicyclists (I), (A), (II).

Bicyclist speeds vary based on age and ability and are a function of many factors, including bicyclist skill, bicyclist physical and cognitive abilities, bicycle design, traffic, lighting, wind conditions, transportation facility design, and terrain. Adults typically ride at 8–15 mph (13–24 km/h) on level terrain, while children ride more slowly. Experienced, physically fit riders can ride up to 30 mph (50 km/h); very fit riders can ride at speeds in excess of 30 mph (50 km/h) but will typically only ride at such speeds on roads.

Table 3-2. Key Performance Criteria

Bicyclist Type	Feature	Value	
		U.S. Customary	Metric
Typical upright adult bicyclist	Speed, paved level terrain	8–15 mph	13–24 km/h
	Speed, downhill	20–30 plus mph	32–50 plus km/h
	Speed, uphill	5–12 mph	8–19 km/h
	Perception reaction time	1.0–2.5s	1.0–2.5s
	Acceleration rate	1.5–5.0 ft/s <sup>2</sup>	0.5–1.5 m/s <sup>2</sup>
	Coefficient of friction for braking, dry level pavement	0.32	0.32
	Deceleration rate (dry level pavement)	0.16 ft/s <sup>2</sup>	4.8 m/s <sup>2</sup>
Recumbent bicyclist	Deceleration rate for wet conditions (50–80% reduction in efficiency)	8.0–10.0 ft/s <sup>2</sup>	2.4–3.0 m/s <sup>2</sup>
	Speed, level terrain	11–18 mph	18–29 km/h
	Acceleration rate	3.0–6.0 ft/s <sup>2</sup>	1.0–1.8 m/s <sup>2</sup>
	Deceleration rate	10.0–13.0 ft/s <sup>2</sup>	3.0–4.0 m/s <sup>2</sup>

Note: The speeds reported are for bicyclists on shared use paths. Experience suggests that maximum speeds on roadways can be considerably higher.