

## Longitudinal Radius of Gyration

We have been able to make numerous measurements of the longitudinal radius of gyration through the center of gravity of the bike/rider,  $K_x$ . There is some correlation between seatback angle and  $K_x$ . The following list are recommended estimates for the designer/builder. Exact measurements require a swing and precise knowledge of the position of the center of gravity.

A vertical man/rider  $K_x = .5$  meters (estimated)

A diamond frame rider  $K_x = .4$  meters (estimated)

A vertical seat recumbent  $K_x = .44$  meters 90 degrees seatback (one measurement)

A reclined seat recumbent  $K_x = .41$  meters 60 degrees seatback (median of 8 measurements)

A laid back seat recumbent  $K_x = .35$  meters 45 degrees seatback (median of 5 measurements)

A laid back seat recumbent  $K_x = .31$  meters 30 degrees seatback (median of 2 measurements)

These are for an axis parallel to the X axis through the center of gravity of the bike/rider, they are not through a principal axis. A very good estimation for the position of the center of gravity is the rider's belly button.



The bike swing is used to determine  $K_x$  for the class project bikes.

### Finding $K_x$

The radius of gyration is an important value for the designer. It's measurement requires a swing fixture to determine the natural frequency of the bike/rider. Measurement may be too difficult for most builders.  $K_x$  is .44 meters for a bike with a vertical seatback and feet lower than the seat bottom. It reduces to .26 for a reclined seat with the feet above the seat bottom.

Below is a photo of our swing fixture and a program that can be used to measure  $K_x$ .

The program below uses English units

```
Kx finder
%
% bike and rider
%          SWING DATA
Mb=208/32.2
h=21.64/12
Tau = 2.1
```

The bike and rider weigh 208 lbs and the cg is 21.6 inches from the floor.

The period of 10 swings is 21 seconds. The period of one swing is then 2.1 seconds.

```
% mass data on fixture (tare)
%
Mp=65.5/32.2
Lp=64.4/12
Ipo = 34
Rp=44.1/12
.
```

The fixture has a steel swing that weighs 65.5 lbs, a cg at 44.1 inches and a mass moment of inertia about the swing axis of 34 slug feet<sup>2</sup>. The distance from the swing axis to the bottom of the swing is 64.4 inches

```
%
%
%total swinging tare plus bike/rider
%
```

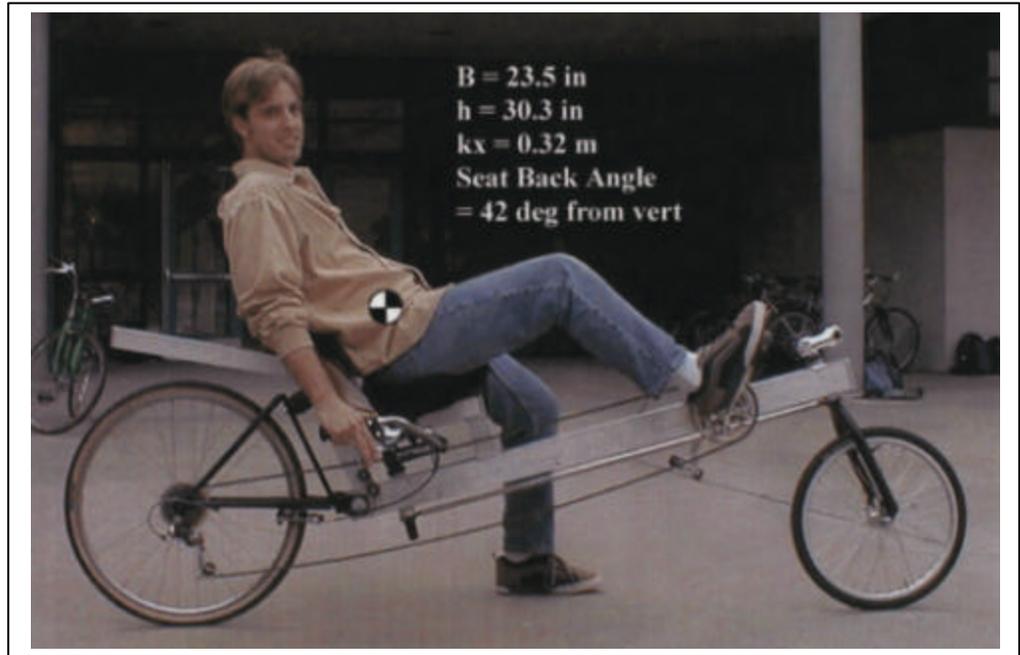
```
Mt= Mb+Mp
Rb = Lp-h
Rt = (Rb*Mb +Rp*Mp)/(Mb+Mp)
WN=2*pi/Tau
Ito = Rt*Mt*32.2/(WN*WN)
```

Ito is the total mass moment of inertia about the swing axis.

```
%
%retrieve bike kx
%
```

$I_{bo} = I_{to} - I_{po}$   
 $I_{bx} = I_{bo} - M_b * R_b * R_b$   
 $K_x = \sqrt{I_{bx} / M_b}$   
 $KX = K_x * 12 * .0254$

KX is converted to meters.



**This is an example of one of our student project bikes. The position of the center of gravity and Kx are noted. Scott's bike will have a somewhat lower Kx because his bottom bracket is even with the seat bottom.**