

# Bike Frames 1

Monday, January 6, 2025 5:53 PM

## Bike Frames Day 1 Learning objectives

- Identify a force as a push or pull acting on an object, and describe forces acting on a bicycle and rider.
- Recognize the basic physical units needed to talk about mechanics and do some basic conversions.
- Explain the force of gravity on everyday objects using the idea that weight depends on mass  $W = mg$
- Draw simple free-body diagrams showing weight, normal force, tension, and applied forces.

## Bike Anatomy



<https://images.contentstack.io/v3/assets/blt964243cdd7810dea/bltf91ef9d568536952/62140bd6cf85c1619ad89e26/bike-anatomy-bike.jpg>

Let's start with units

Concept	Meaning	SI unit	symbol	Other crazy units	Conversion factors
Distance	Width, length, how far apart	meter	m	Feet (ft), inches (in), miles (mi)	1 inch = 2.54cm 1 mile = 5280 ft 1 km = ~1.6 mile
Time	How long something takes	seconds	s	Hours, days, years,	
Mass	Not weight.... F=ma	Gram	G	Lb, oz, tonnes	1kg = 2.2 lb 1lb = 16 oz
Force	Push or pull acting on an object	Newtons	N		
Area	Area	Meter <sup>2</sup>	$m^2$	$in^2$	$1in^2 = 6.452cm^2$
Velocity	Speed & direction	Meters / second	m/s	Mph, kmh, speed of light c	
Acceleration	Rate of change of velocity	Meters / seconds <sup>2</sup>	$m/s^2$	G-forces	
Stress (pressure)	Force distributed over an area	Pascal	Pa	Psi, torr, barr,atm	1psi = 6894Pa

A few bike examples

- A bike is ~1.5 m long
- A pedal stroke lasts ~1 s
- A rider has a mass of 75 kg
- Pedal forces are ~200-600 N
- Gravity on earth is  $9.8 \text{ m/s}^2$ , gravity on mars is only  $3.72 \text{ m/s}^2$

$$F = ma$$

### Let's do a few conversions

- The upcoming Tour de France is 3,333 km. How many miles is this?

$$\begin{array}{c|c|c|c|c} 3333 \text{ km} & 1000 \text{ m} & 3.28 \text{ ft} & 1 \text{ miles} & \rightarrow 2070 \text{ miles} \\ \hline & 1 \text{ km} & 1 \text{ m} & 5280 \text{ ft} & \end{array}$$

- You can ride your bike at 18 mph. What would this be in m/s?

$$\begin{array}{c|c|c|c|c} 18 \text{ miles} & 1 \text{ hr} & 1 \text{ min} & 1609 \text{ m} & 8.04 \frac{\text{m}}{\text{s}} \\ \hline \text{hr} & 60 \text{ min} & 60 \text{ s} & 1 \text{ mile} & \\ \hline 18 \text{ m/hr} & 1 \text{ hr} & 1 \text{ min} & 1 \text{ m/s} & \\ \hline \text{hr} & 60 \text{ min} & 60 \text{ s} & 1609 \text{ m} & \cancel{\frac{\text{miles}^2}{\text{s m}}} \end{array}$$

- Danny MacAskill is arguably one of the world's greatest bike trials rider. He weighs ~160 lbs. Convert this to kg.

$$\begin{array}{c|c} 160 \text{ lb} & 1 \text{ kg} \\ \hline 2.2 \text{ kg} & \end{array} = 72 \text{ kg}$$

- Convert a bike frame tube diameter from 2 inches to mm.

$$\begin{array}{c|c|c} 2 \text{ in} & 2.54 \text{ cm} & 10 \text{ mm} \\ \hline 1 \text{ in} & 1 \text{ cm} & \end{array} 50.8 \text{ mm}$$

- A biker has a 90 rpm stroke cadence. What would this be in radians/s?

$$\begin{array}{c|c|c} 90 \text{ rot} & 1 \text{ min} & 2\pi \text{ rad} \\ \hline \text{min} & 60 \text{ s} & 1 \text{ rot} \\ \hline & & \end{array} 9.242$$

What exactly is a Newton???

1 Newton is the force needed to accelerate 1 kg of mass by 1 m/s<sup>2</sup>.

$$F = m \cdot a$$

So what is the "force of gravity" ?

Gravity creates a "downward" force on everything

1. Gravity gives weight.

2. Weight depends on mass.

$$W = mg$$

What forces act on a bicycle?



<https://www.pinkbike.com/news/fezzari-bicycles-rebrands-to-ari-and-announces-new-lightweight-all-mountain-emtb.html>

Free body diagrams

A bike is a complex object made up of dozens of smaller components and forces. A free body diagram let's us simplify the picture, isolate what matters, and ignore what doesn't.

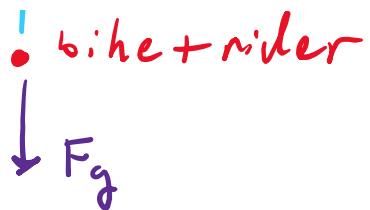
Rules:

1. Replace the object with a dot/box.
2. Draw arrows showing forces
3. Label direction clearly
4. Arrow length is typically proportional to the relative strength

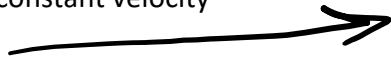
**Let's do free body diagrams for three scenarios**

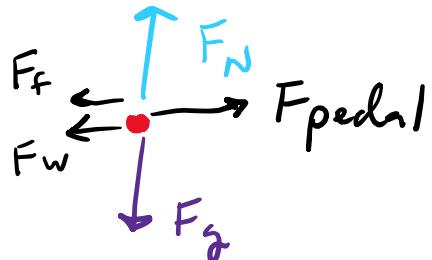
1. Bike and rider standing still





2. Pedaling forward on a flat road at a constant velocity





3. Braking hard

The bike slows down, or **decelerates** because there is a **net force** in the opposite direction of the velocity  
This is Newton's 2nd Law of Motion!

$$F = ma$$

We can actually use this to derive the  $9.8 \text{ m/s}^2$  gravity value for earth!

Universal Gravitation equation

$$F = G \frac{m_1 m_2}{r^2}$$

$$F = ma$$

$$m_1 a = G \frac{m_1 m_2}{r^2}$$

where  $G$  is  $6.674 \times 10^{-11} \text{ N} \frac{\text{m}^2}{\text{kg}^2}$  and Earth's mass is  $5.972 \times 10^{24} \text{ kg}$  and earth radius is  $r = 6.371 \times 10^6 \text{ m}$

$$5.972 \times 10^{24} \text{ kg}$$

$$11.11 \text{ m/s}^2$$

$$5.972 \times 10^{24} \text{ kg}$$

