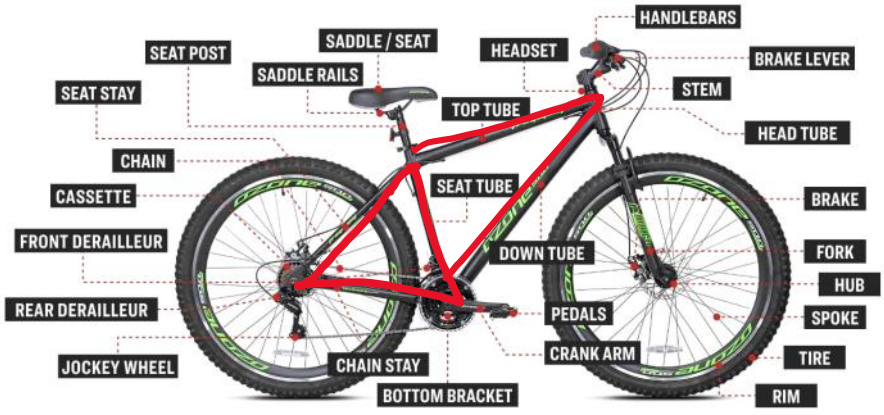
Bike Frames 1

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^2	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^2	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 $9.8\ m/s^2$, gravity on mars is only $3.72\ m/s^2$

$F = ma$

Let's do a few conversions

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

$$\frac{3333\ km}{} \cdot \frac{1000\ m}{1\ km} \cdot \frac{3.28\ ft}{1\ m} \cdot \frac{1\ miles}{5280\ ft} \rightarrow 2070\ miles$$

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

$$\frac{18\ miles}{hr} \cdot \frac{1\ hr}{60\ min} \cdot \frac{1\ min}{60\ s} \cdot \frac{1609\ m}{1\ mile} = 8.04\ \frac{m}{s}$$

$$\frac{18\ miles}{hr} \cdot \frac{1\ hr}{60\ min} \cdot \frac{1\ min}{60\ s} \cdot \frac{1\ mile}{1609\ m}$$

$$\frac{miles^2}{s\ m}$$

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

$$\frac{160\ lb}{} \cdot \frac{1\ kg}{2.2\ lb} = 72\ kg$$

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

$$\frac{2\ in}{} \cdot \frac{2.54\ cm}{1\ in} \cdot \frac{10\ mm}{1\ cm} = 50.8\ mm$$

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

$$\frac{90\ rot}{min} \cdot \frac{1\ min}{60\ s} \cdot \frac{2\pi\ rad}{1\ rot} = 9.242$$

What exactly is a Newton???
1 Newton is the force needed to accelerate 1 kg of mass by 1 m/s².

$F = m\,a$

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.

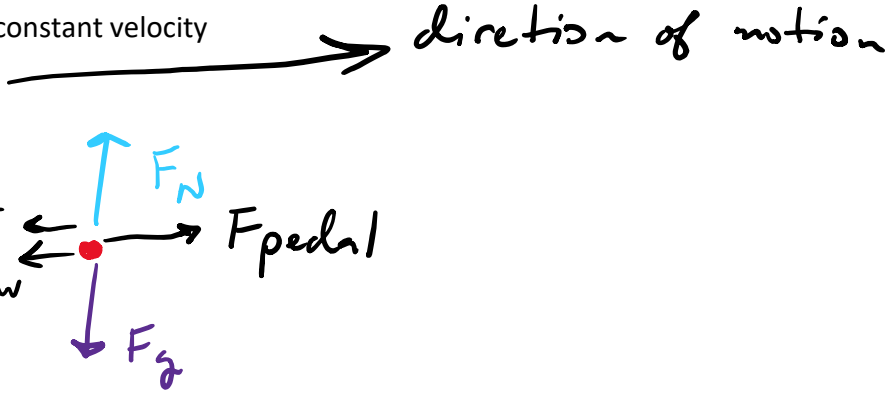
Rules:

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 $9.8\ m/s^2$ gravity value for earth!

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

Universal Gravitation equation

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

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

$5.972 \times 10^{24}\ kg$ $\quad$ r_1 r_2

5.972×10^{24} kg